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WEEKLY December 13 - 19, 2014

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on the internet

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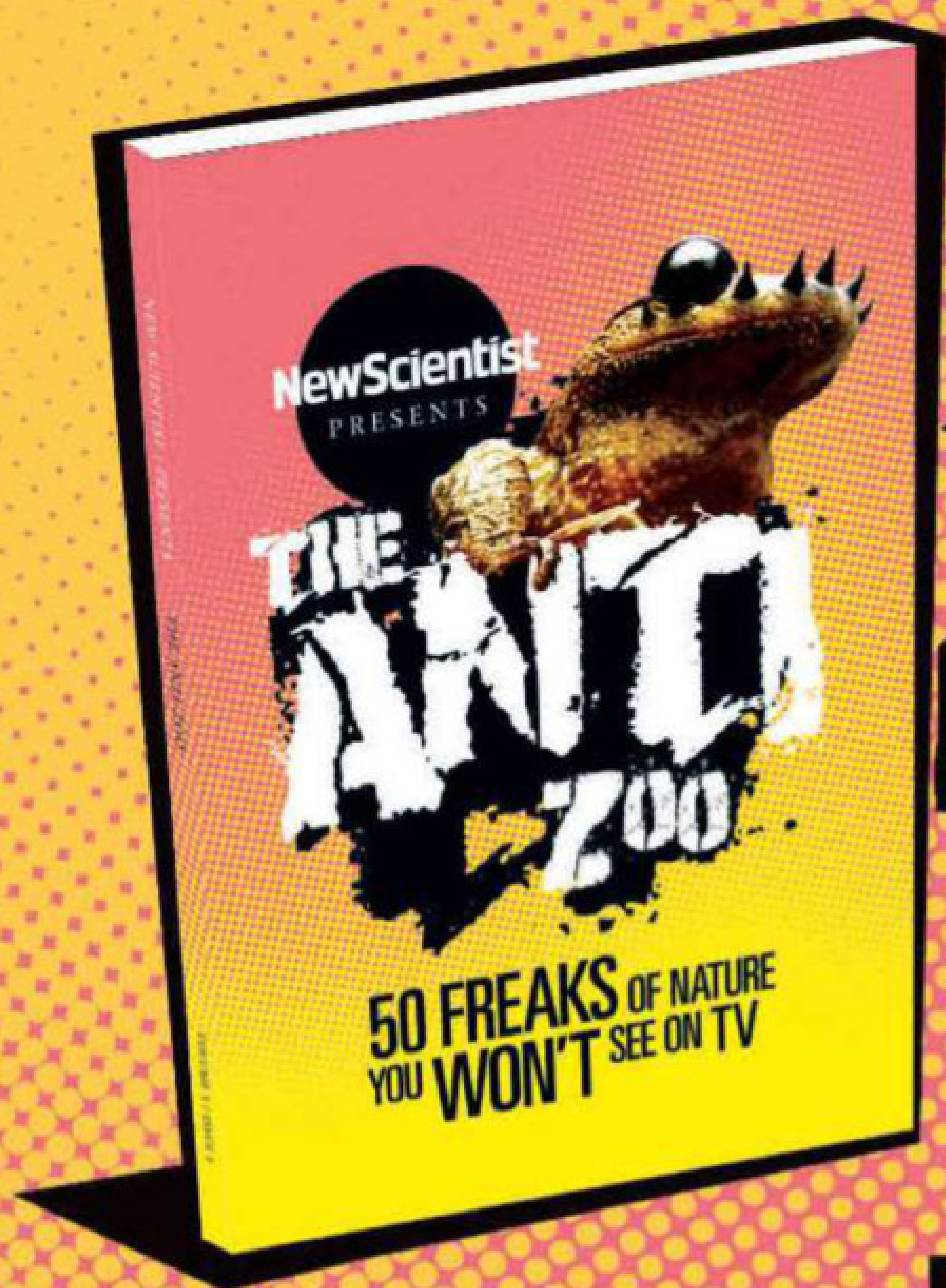
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ALY SONG/REUTERS

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Sales and Marketing, 260 Cherry Hill
Road, Parsippany, NJ 07054

Syndication

Tribune Content Agency
Tel 800 637 4082

© 2014 Reed Business
Information Ltd, England.

New Scientist ISSN 0262 4079 is
published weekly except for the last
week in December by Reed Business
Information Ltd, England.

New Scientist at Reed Business
Information, c/o Schnell Publishing Co.
Inc., 225 Wyman Street, Waltham,
MA 02451.

Periodicals postage pending at
Boston, MA and other mailing offices.

Postmaster: Send address changes
to New Scientist, PO Box 3806,
Chesterfield, MO 63006-9953, USA.

Registered at the Post Office as a
newspaper and printed in USA by Fry
Communications Inc, Mechanicsburg,
PA 17055



PHOTO MONTAGE / KEN WELSH / ALAMY

Finding the right balance

All of us have a responsibility to stamp out online abuse

DOES technology create spaces that are beyond the law? The issue of who should take responsibility for stamping out online abuse might make it seem so.

This year has been marked by mounting concern about online hate speech, from Islamist to misogynist. But who should decide when a post goes too far? Last week Peter Fahy, chief constable of Greater Manchester Police, said he and his colleagues in the security establishment should not be left to judge when unpopular opinions become actionable abuse. That, he warned, risked “a drift to a police state”. He might have added that the sheer volume of such cases defies conventional policing.

Unconventional policing, then? It is tempting to ask the tech companies behind the social media boom to build tools that can automatically spot abuse and address it. But even a spotting system orders of magnitude better than anything available today would generate huge numbers of false positives when dealing with, say, Facebook traffic.

Many such companies have been reluctant to engage with this issue, citing a generally admirable commitment to freedom of speech. And they are loath to act as anything other than a carrier of messages, although that stance is growing hard to square with their desire to store and analyse every last scrap of our personal data.

But just because there is no easy balance doesn't mean we should give up. And indeed, hands-off attitudes are giving way to more active governance (see page 20). Ultimately, the state, the tech giants and their users will have to work in concert to make online spaces more civil. That's as it should be: the best policing is by consent, not diktat (see page 10).

For that, the state must eschew the temptation to overreach, even with the best of intentions. Tech giants must stop posturing as cocky upstarts and live up to their responsibilities as corporate citizens. And individuals will have to start thinking harder before they hit “send”. It's time we lived up to our responsibilities, too. ■

The wrong kind of water

IT'S hard to think of two more wildly different possibilities: did life on Earth get its start amid the gentle bubbles of a “warm little pond”, as Darwin put it, or was it born amid the colossal blows of space rocks slamming into our young planet?

The Rosetta spacecraft has now found water in the coma of comet 67P – the tenuous envelope of gas forming around the comet as it

approaches the sun. That's not unexpected: water has already been detected in other comets.

What was unexpected is that it's not the same kind of water that we find on Earth: it is much richer in heavy hydrogen (see page 12). That's a complication for the idea that comets delivered vast quantities of water to early Earth. Other comets do have Earth-like water, though, and an analysis of

lunar rocks suggests the moon's water may have come from meteorites (see page 16). If the Rosetta result holds up, we'll have to explain why we haven't seen more comets with heavy water.

But life here may have begun differently. The four bases that make up RNA have been created by mimicking meteorite impacts on early Earth – an environment where water was scarce (see page 11). It's a long way from life, but our own kind of big bang may have sparked it. ■

Curiouser and curiouser

IF IT had landed on Mars a few billion years earlier, NASA's Curiosity rover would have needed flippers. It has found sediments that show Gale Crater was once a large lake that might have stuck around long enough for life to get started. Mars may also have been humid, with a complex weather system.

"We think that's what we're seeing here: lake floor deposits," says John Grotzinger of the California Institute of Technology in Pasadena.

Curiosity has also solved the mystery of how a 5-kilometre-high mountain got to be in the middle of a crater. Cycles of wet and dry periods seem to have filled up the crater with sediment that was later eroded, leaving the peak, Mount Sharp, that remains today.

But how could such a large lake exist on Mars? "The climate system must have been loaded with water," says Ashwin Vasavada of NASA's Jet Propulsion Laboratory in Pasadena - meaning that Mars may have had an ocean.

The sediment seems to have been laid down in bursts of hundreds of thousands to millions of years, suggesting that the lake periodically evaporated: this could be an indication of climate cycles caused by volcanic activity or meteorite impacts. "The question is," says Vasavada, "could temporary climate fluctuations form what we see geologically, or do we need longer-term warm, wet climate?"

Answering that question could indicate whether there was enough time for life to emerge on the planet.



Previously a lake

Malaria on the run

HURRAH for bed nets, rapid diagnosis and drugs called artemisinins. Together, they have helped to halve the death rate from malaria between 2000 and 2013, saving an estimated 4.3 million lives.

This is according to the *World Malaria Report 2014*, released this week in London by the World Health Organization. Half a million people died from malaria in 2013 and there were 200 million cases globally.

"We have the right tools, but we still need to get those tools to a lot more people"

"We have the right tools and our defences are working, but we still need to get those tools to a lot more people if we are to make these gains sustainable," says Margaret Chan, the director-general of the WHO.

In sub-Saharan Africa, where 90 per cent of malaria deaths occur, new infections have fallen by 26 per cent from 173 million in

2000 to 128 million last year, despite a 43 per cent increase in population.

This is in part thanks to bed nets impregnated with insecticides that kill malaria-carrying mosquitoes. These insecticides can now work for up to five years, and half of the people at risk in the sub-Saharan region were using bed nets in 2013, up from just 3 per cent of people a decade ago.

Medical advances have played a role too. The use of rapid diagnostic tests has risen six-fold, and patients received almost 400 million courses of powerful artemisinin-based therapies last year, up from just 11 million in 2000.

But gaps and problems remain, says Pedro Alonso, the director of the WHO's malaria programme. A third of households at risk from malaria in sub-Saharan Africa still don't have bed nets, and fears remain that resistance to artemisinins that has emerged in five Asian countries may eventually engulf Africa.

The WHO says it still needs more than \$2.5 billion to reach global malaria targets.

Food fail

WHAT a waste. Almost 98 per cent of unsold supermarket food ends up being burned or dumped in landfill sites, reveals a report issued this week by UK members of parliament. Only 2 per cent of this perfectly edible surplus food gets sent to food banks, the *Feeding Britain* report found.

The failure of wages to track food prices has led to rising hunger. Since 2003, earnings have risen by 28 per cent, compared with a rise of 46 per cent in the

cost of food. Dependence on food banks has soared as a result.

Statistics from the Trussell Trust, a charity that organises food banks, show that in the first half of this year almost half a million people were dependent on food handouts, a rise of 38 per cent from the same period in 2013. The trust now runs 420 food banks, compared with almost none in 2004. Currently, the public donate 90 per cent of the food that the trust distributes, which is why the report calls on supermarkets and manufacturers to do more.

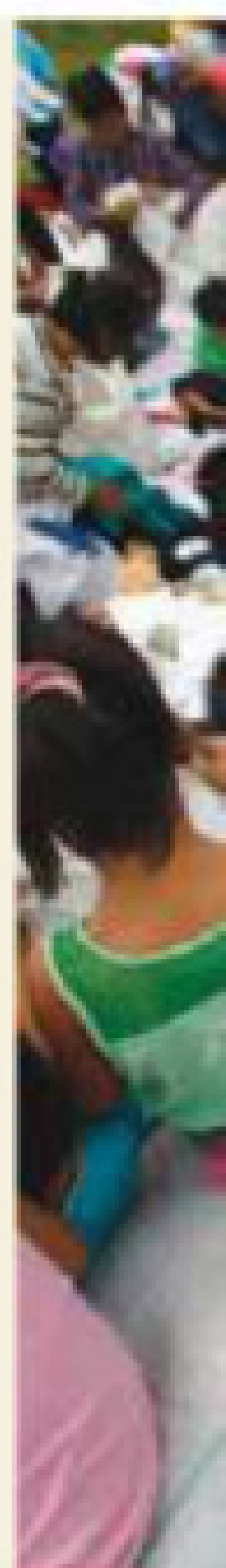
Took a hint from typhoon Haiyan

IT'S a big difference. The death toll from typhoon Hagupit that hit the Philippines this week was around 20. When typhoon Haiyan hit the country last year some 7000 people died. So what was different this time round?

For a start, this storm was marginally less intense. And, unlike Haiyan, it did not drive a tidal surge up an estuary to slap into the city of Tacloban. But the biggest difference, say international rescue agencies, is

that this time the government was prepared. More than 1000 evacuation shelters were ready and stocked with food, with an estimated 1.7 million people kept safe in public buildings or on high ground.

Haiyan taught the Philippines that it was vital "to evacuate before the storm hits, if you live near the sea, and if you live near trees whose branches might fall on you", said Richard Gordon, the chairman of the Philippine Red Cross.



Orion flight

ONE small step for a spacecraft, one giant wait for humankind. On 5 December, NASA launched the first test flight of its Orion space capsule, designed to take humans beyond low Earth orbit and perhaps one day to Mars.

REUTERS/CHARLES PLATIAU



Time to slow emissions down

Saying 'non' to NO_x

LOOKING for a new car? Reasons to avoid a diesel one are mounting. The pollutant-emitting cars could be banned from the streets of Paris in six years' time.

The move, if enacted, would make Paris the first major metropolis to ban diesel cars from its heart. "The measure is clear: I want the end of diesel in Paris in 2020," the city's mayor

"If clean air is the objective, finding alternatives to diesel vehicles needs to be a priority"

Anne Hidalgo told the newspaper *Le Journal du Dimanche*.

The main rationale is to reduce heart and lung disease linked with breathing in nitrogen oxides from the air. Diesel cars have become increasingly popular because they discharge less carbon dioxide, but they release about four times as much NO_x as petrol-fuelled cars.

Figures published by the European Environment Agency last month show that Paris has an annual mean concentration of nitrogen dioxide of 82.5 micrograms per cubic metre of air – twice the EU limit. But London tops the table, with an annual mean concentration of 94 micrograms, and has been

threatened with an EU fine for consistently failing to meet air-pollution targets.

Diesel emissions are a major source of pollution in a number of European cities, says Frank Kelly, an environmental scientist at King's College London. "If clean air is the objective, finding alternatives to diesel vehicles needs to be a priority," he says.

Ebola medic strike

TIME to take action. Doctors in a Sierra Leone hospital have gone on strike to protest a lack of vital medical supplies during the Ebola outbreak. The action by the Junior Doctors Association comes days after three doctors died at Freetown's Connaught hospital.

Staff want respirators and vital signs monitors, among other devices, and have complained of low morale and fears over exposure to the virus. British Ebola survivor and medic Will Pooley is based at the hospital, although his ward is reported to be unaffected by the strike.

Sierra Leone has had more than 1700 Ebola deaths in 2014 – the highest total of cases in West Africa. David Nabarro, the UN Secretary General's special envoy for Ebola, this week called for more foreign health workers to help contain the virus, which is still spreading in Sierra Leone.

60 SECONDS

Coral smell-o-vision

The harlequin filefish blends in with its habitat to avoid predators: not only does it look like coral, it smells like it too. The fish matches coral's smell by eating it and incorporating its odour chemicals, which disguise it from predators (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2014.1887).

Not-so minty fresh

People who smoke menthol cigarettes often smoke more frequently and can be less likely to quit. Last month, the Society of Neuroscience in Washington DC heard that menthol exposure increases the number of nicotine receptors in a brain region involved in addiction, as shown by experiments in mice.

End of the line

The European Space Agency's Venus Express probe may have finally run out of fuel after eight years in orbit around the hellish planet. The spacecraft survived a swan dive into Venus's atmosphere earlier this year in a last-ditch attempt to eke out data from the mission, but now ESA says it has limited contact with the probe, which may burn up in the atmosphere in the next few weeks.

Bug business class

House dust mites are keen air travellers. A study of the bugs in south Asia and the US revealed genetic mutations in local populations that could only be explained by intercontinental dispersal. The mites were probably carried on air passengers' clothes, skin and baggage (*PLoS One*, DOI: 10.1371/journal.pone.0114636).

Drones take flight

Amazon could relocate its outdoor testing of delivery drones outside the US, after being frustrated by negotiations with the US Federal Aviation Administration. The firm has already begun flight tests in other locations.



CHERYL GAGALAC/REUTERS

Better prepared

On the road to a climate fix

Is optimism at the latest climate summit enough to create a deal? **New Scientist** investigates

THE world is set to warm by more than 2°C by 2100, which puts us on track to dangerous climate change. But UN climate negotiators meeting in Peru's capital Lima this week are optimistic that they can reach an agreement on planet-warming gases.

In a bid to improve the chances of a binding climate deal in Paris next December, the process has been split into a number of stages. As part of the timetable, major nations are expected to make formal promises on cutting their emissions by the end of March. A prime task of the Lima meeting is to decide what those national promises should include.

The three biggest players have already put their cards on the table. The 28 nations of the European Union have committed to cut emissions to 40 per cent below 1990 levels by 2030. And last month a historic agreement was reached by the world's top two emitters: the US and China (see "Green stirrings", right).

Cash is also trickling in for the Green Climate Fund to help poor nations - the innocent parties in global warming - adapt to changing climate. But the promises are just under \$10 billion - far short of the \$100 billion a year that rich nations agreed to mobilise by 2020 during the ill-fated negotiations in Copenhagen in 2009. The UN Environment Programme says three times that will be needed before mid-century.

The wrangling at Lima has already begun. One question is whether nations at different stages of economic development should make different promises. Brazil has proposed three categories: developed nations with firm emissions targets; middle-ranking nations like itself, which would have targets based on

reducing the carbon intensity of their economies; and least-developed nations without firm targets.

Also, many developing countries are demanding that rich nations' promises should include cash contributions to the Green Climate Fund - something the European Union and others have rejected.

There are wild cards in Lima. Russia, the world's fourth largest emitter and a major exporter of fossil fuels, has fallen out with fellow industrialised

"Climate scientists are hoping for a firm goal to cut emissions by up to 80 per cent by 2050"

nations. And a new government in India, the world's third largest emitter, has yet to declare its hand.

Despite the diplomatic optimism, climate scientists are wary about whether a deal in Paris will do enough to limit warming to 2°C. They hope for a firm goal to cut emissions by up to 80 per cent by 2050 - even if it is fuzzy about how to achieve it.

But old hands are warning against high expectations. Former chief UN climate negotiator Yvo de Boer says that the meeting in Paris is unlikely to deliver a science-driven deal. He says any agreement is more likely to resemble the Kyoto protocol, with ad hoc national pledges. And Nicholas Stern of the London School of Economics said this week that even a legally binding agreement might be out of reach, and possibly counter-productive. Making targets binding would discourage ambition, he said.

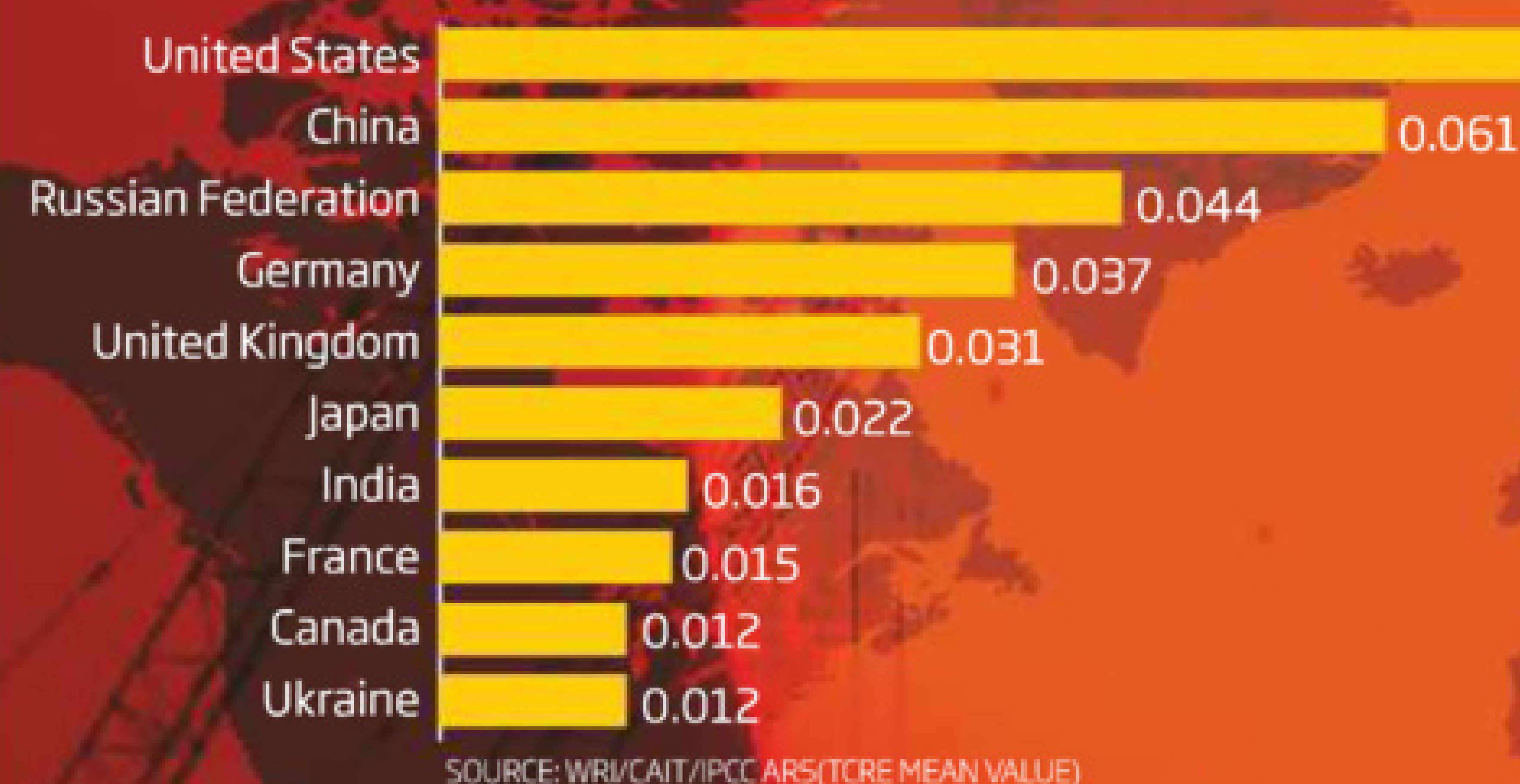
The question is whether diplomacy can match the real climate. With 2014 set to be the hottest year on record, the stakes are rising. **Fred Pearce** ■

What's at stake

Earth's average temperature has risen by 0.85°C since the industrial revolution. Industry is largely to blame, alongside deforestation and large-scale farming. To avoid warming of 2°C, emissions will need to be drastically cut and much of the remaining fossil fuels will have to stay in the ground

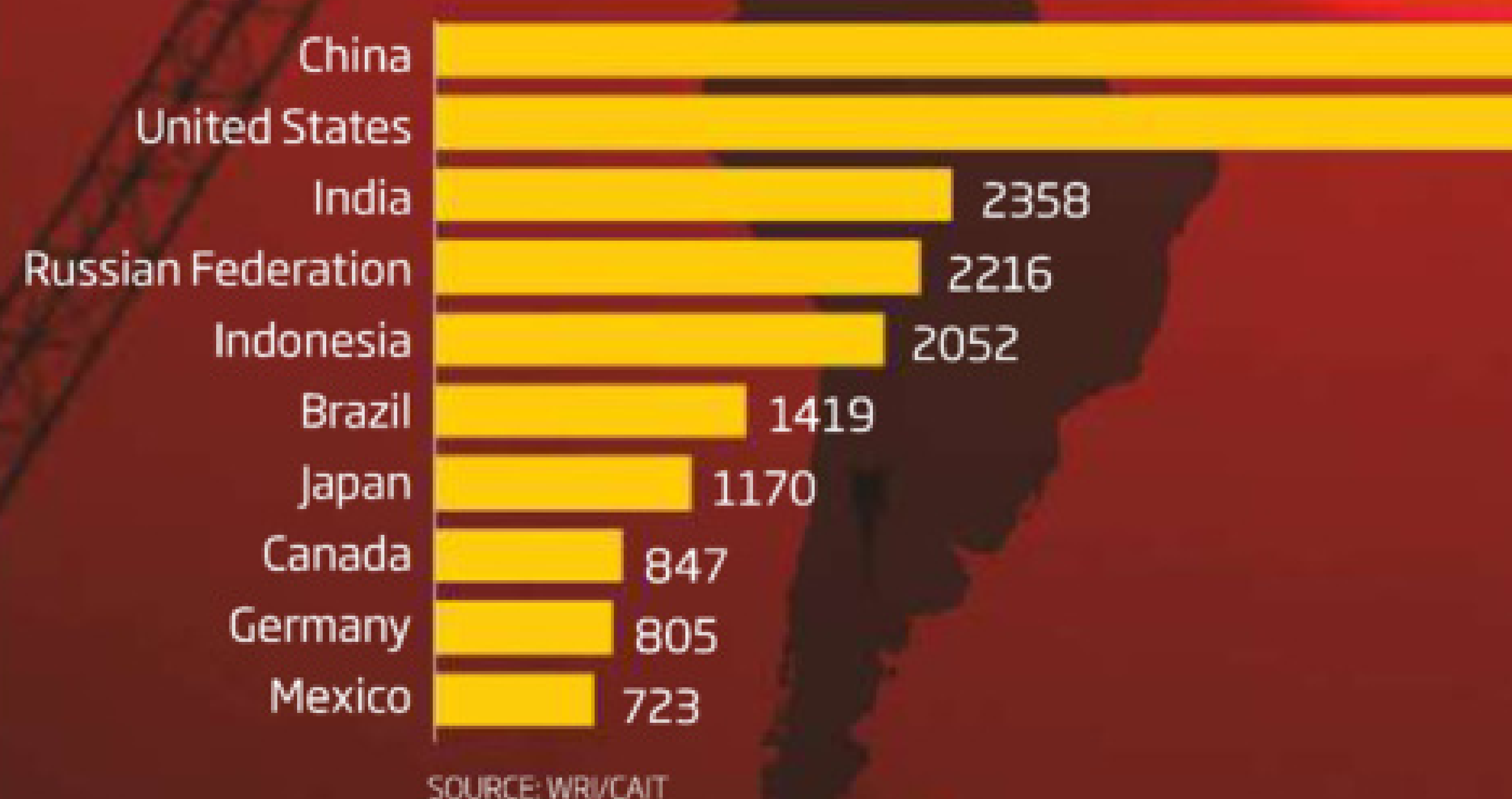
TOP TEN WARMERS

These are the worst-offending countries when it comes to warming the world with industrial CO₂ emissions



NEW WORLD ORDER

The list is somewhat different if you look at annual emissions. Rapidly developing nations now contribute more each year than the usual suspects



CARBON BUDGET

For a 66 per cent chance of avoiding 2°C of global warming, much of the remaining fossil fuel reserves will have to stay in the ground



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Green stirrings

Emissions need to be cut - there's no question about that. Since 2009, many countries have set themselves voluntary targets, including, most recently, the US and China (see below)

US PLEDGES

- Cut greenhouse gas (GHG) emissions to 14-16% below 1990 levels by 2025
- Cut GHG emissions by 80% below 1990 levels by 2050

CHINA PLEDGES

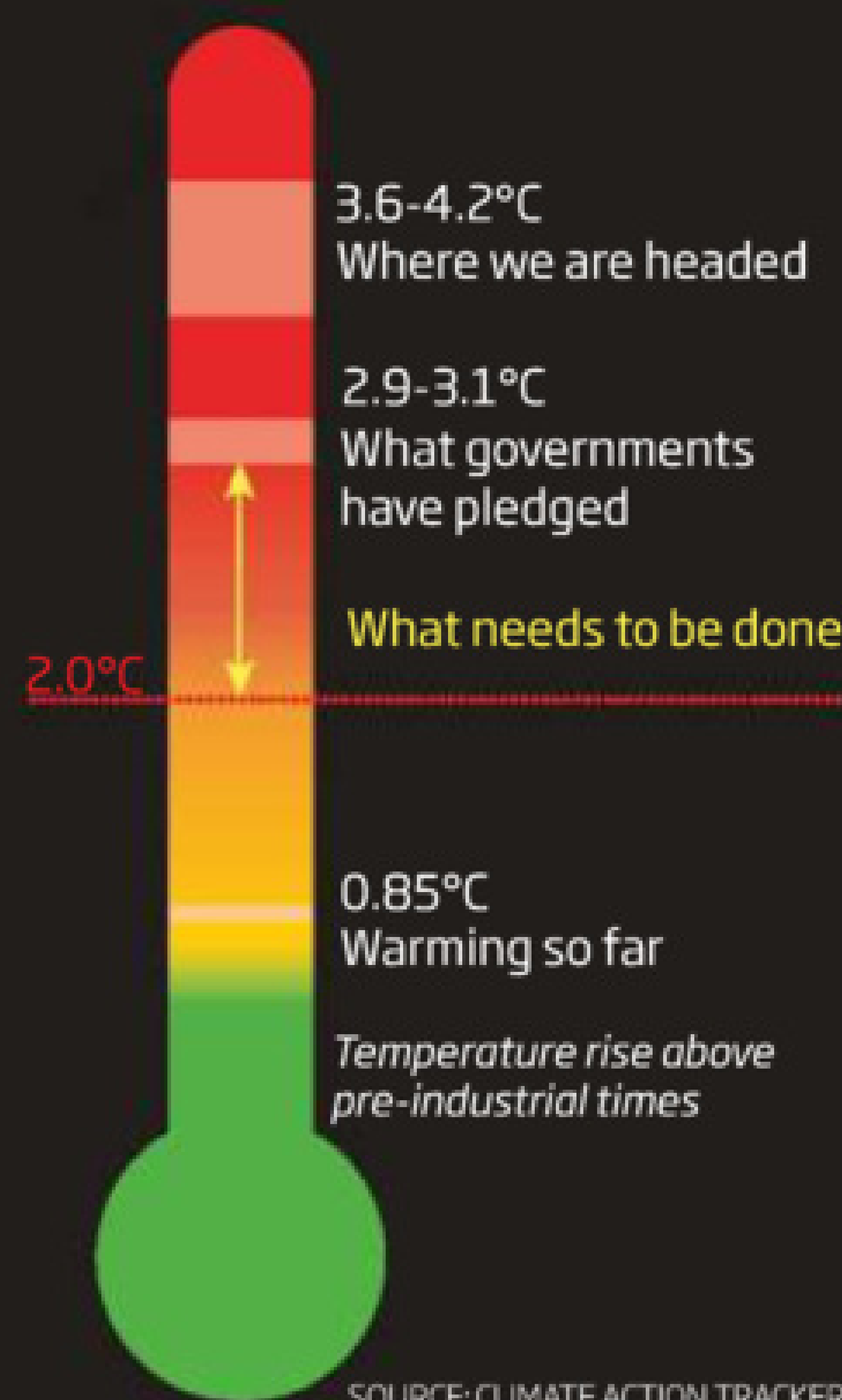
- Peak CO₂ emissions by 2030
- Ensure about 20% of energy comes from renewables by 2030

EU PLEDGES

- Cut GHG emissions to at least 40% below 1990 levels by 2030
- Ensure at least 27% of energy comes from renewables by 2030

WHAT IT ALL ADDS UP TO

Existing green policies around the world set us on track for up to 4.2°C of warming by 2100. Even if governments follow through with their pledges, the world will still warm by up to 3.1°C. So, much more needs to be done to save us from dangerous global warming



SHOW ME THE MONEY

Cutting emissions and adapting to the changing climate costs money. Governments need to do things like devise ways of saving fuel and build sea defences. Many poor nations don't have the cash to do this, so the UN is working on a way to channel money to poor nations from rich ones - traditionally the biggest polluters. The centrepiece is the Green Climate Fund, which has so far raised \$9.95 billion - but, as shown below, this is nowhere near enough.

\$100_{bn}

How much developing countries will need each year, by 2020. A recent report from the UN Environment Programme suggested the real figure might be two to three times as big

\$10_{bn}

Fundraising target for the Lima summit

\$9.95_{bn}

Amount raised as *New Scientist* went to press

Even with these funds, many developing countries will experience severe damage and losses as a result of things like more extreme weather events predicted with climate change. Last year, the UN opened talks about how to help them cope. This is seen by many as a compensation scheme, because the rich largely caused the problem and the poor will suffer many of the worst consequences. How it will work is - for now - anyone's guess. ■

0.157

Contribution to global warming based on industrial emissions from 1850 to 2011

10,260

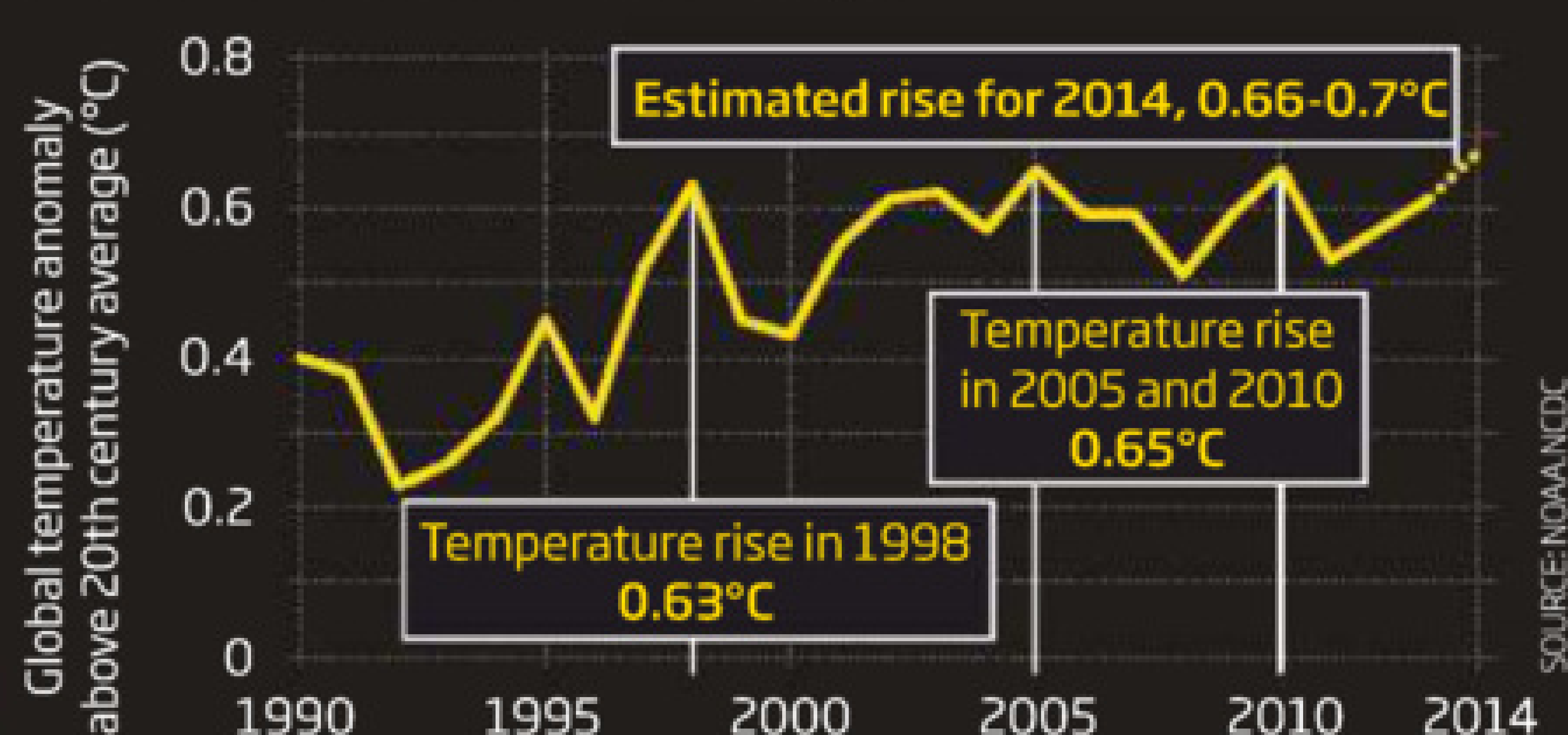
6135

CO₂e

Greenhouse gas emissions in 2011
(megatonnes of CO₂ equivalent)

A DANGEROUS TREND

The 10 warmest years on record all happened since 1998 and 2014 is set to be the hottest yet



INSIGHT Law enforcement



STEPHEN LAM/REUTERS

Strong arm of the law

Why are police in the US so violent?

Hal Hodson

MICHAEL BROWN, Eric Garner, Tamir Rice. These are just the most high-profile police killings that have taken place in the US since July. They have sparked protests around the country, and researchers say they are symptomatic of police becoming dangerously out of kilter with the communities they are meant to

protect and serve.

Why are police in the US so violent? Brown and Garner were stopped for the most minor of reasons – jaywalking in Brown's case, while a police officer choked Garner to death after accusing him of hawking cigarettes. Rice was just 12 years old, playing with a toy gun in a playground when he was shot.

Although statistics on how often police kill someone in the

US are sketchy, the FBI reported 461 "justifiable homicides" in 2013. Other efforts to assess police killings through media reports have recorded more than double that number.

William Terrill, who studies police behaviour at Michigan State University in East Lansing, says the "broken windows" style of policing, in which officers crack down aggressively on minor infractions like fare-dodging and graffiti, may be partly to blame. Communities with high levels of poverty and high proportions of non-white residents are often the focus of broken-windows operations. This can cause a

feeling among citizens that police are constantly harassing them.

"That aggressive crime-fighting style comes at a cost," Terrill says.

"Sometimes you may garner more social capital with the community by not acting, especially with these low-level crimes," he says. "Maybe I'm just going to say, 'I'm gonna take a drive and would you guys mind moving on before I get back?'"

The most egregious police violence could be avoided by giving officers empathy training to help them see those committing crimes as people, Terrill argues. He points to San Diego in California and Madison in Wisconsin as cities on the right path with their police forces. "They make the same number of arrests [as other cities] but they don't use force nearly as much," he says.

Treating police and the communities they serve as a system – rather than a series of isolated events – can help as well, says Rod Brunson, who studies police-community relations at Rutgers University in Newark, New Jersey. "It's not just one interaction that happens between individual officers and citizens; it's a cumulative and repeated set of interactions," he says. "If you listen to the Eric Garner audio, he made some reference to 'this happens every day, why are you all bothering me again?' It feels like harassment." ■

Cosmic rays give galaxies their shapes

WINDS driven by charged particles hurtling through space may be responsible for the elegant spiral shape of our galaxy.

A galaxy typically starts out as a giant clump of roiling gas and dark matter. Spinning flattens out its shape somewhat, but that can't explain the stately disc structure of mature galaxies like the Milky Way. Cosmic

winds are one possible explanation: they could blow material out of the plane of the galaxy, driving it outward and forcing galaxies to become flatter and thinner. But how such winds arise has been a mystery.

Munier Salem at Columbia University in New York and his colleagues think cosmic rays are the creators of this galactic pottery wheel. They developed a simulation that showed these charged particles, which hurtle out of the bowels of stars when they explode as supernovas and zip across galaxies at close to the speed of light, could drive winds

strong enough to shape galaxies (arxiv.org/1412.0661).

Cosmic rays don't interact much with the gas of interstellar space, but they do interact with magnetic fields. "They push the field lines around, and the field lines push the gas around," says Salem. That creates winds – gusts of material moving around the young galaxy.

"I think their work is an important

"For the first time we have simulations showing cosmic ray effects in a Milky Way-sized galaxy"

step," says Torsten Enßlin of the Max Planck Institute for Astrophysics in Garching, Germany. Cosmic winds are an essential ingredient of galaxies, he says.

"I am especially impressed by the fact that these simulations show for the first time such cosmic ray-driven outflows in cosmological simulations of a Milky Way-sized galaxy," says Christoph Pfrommer of the Heidelberg Institute for Theoretical Studies in Germany. "We are progressing fast towards a predictive theory of galaxy formation, which is very encouraging." Hal Hodson ■

Fake meteorite strike makes life's ingredients

TALK about making an impact. One of the meteorites that slammed into the planet early in its history could have kick-started life: the collision may have generated all four bases in RNA, suggests a lab experiment.

Life appeared on Earth around 4 billion years ago, about the same time that the planet was being pelted with large meteorites – an event called the Late Heavy Bombardment. That's no coincidence, as far as Svatopluk Civiš at the Academy of Sciences of the Czech Republic in Prague and his colleagues are concerned.

They simulated a meteorite impact on early Earth by firing a high-power laser at samples of formamide – a liquid that would have existed on our primordial planet. The sample temperatures soared to 4200°C, generating X-rays and extreme ultraviolet radiation that reacted with the formamide to create chemical

radicals. These radicals, in turn, reacted with the remaining formamide to generate 2,3-diaminomaleonitrile – DAMN for short – which is a chemical precursor to the nucleobases.

Examining the end products of the reaction, Civiš and his team found all four RNA bases: adenine, guanine, cytosine and uracil – three of which are also found in DNA (*PNAS*, [doi.org/xm8](https://doi.org/10.1073/pnas.1212128109)).

The work “nicely correlates the Late Heavy Bombardment and the energy that it delivered to Earth with the formation of RNA and DNA nucleobases from formamide”, says Steven Benner at the Foundation For Applied Molecular Evolution in Gainesville, Florida.

“This is the first time that solid theoretical treatment and experimental data are presented together,” says Ernesto Di Mauro at the Sapienza University of Rome, who first suggested in

2001, with Raffaele Saladino at the University of Tuscia, that formamide played a role in the origin of life.

Even more biologically important molecules can be generated if minerals inside the meteorites acted as catalysts, says Di Mauro, whose as-yet-unpublished work has explored this. “The obtained products are astonishingly rich and variegated,” he adds.

Saladino and Di Mauro suggested formamide would have concentrated in warm lagoons on our young planet – particularly

“It's no coincidence life appeared on Earth around the same time it was being pelted by large meteorites”

because it has a higher boiling point than water, so would concentrate as water evaporated.

Donald Lowe, a geologist at Stanford University who studies the Late Heavy Bombardment, says such environments did exist on early Earth – despite the disruption caused by the impacts.

“Lagoons or, in more general terms, shallow-water protected settings, are likely to have been well developed on the early Earth,” says Lowe.

Civiš's team is now trying to address how the RNA bases came together with other complex molecules to form RNA. For instance, they hope to generate carbohydrates with similar laser experiments.

Saladino and Di Mauro's work suggested that the first, small RNA molecules were most likely to come together in a water-free environment – like a formamide-rich lagoon.

Benner points out that some geologists think early Earth had too much water for these environments to exist, and suggests that the reactions may have occurred on the much drier early Mars, before life later reached Earth on meteorites. **Colin Barras ■**

First primates may have lived with dinosaurs

THE earliest primates may have scuttled round dinosaurs' feet. Finds in Montana have revealed a species so different from others that scientists have more evidence that the first primates evolved when dinosaurs still roamed. The animal, living in the early Palaeocene epoch, just after dinosaurs died out about 65 million years ago, weighed between 500 and 1500 grams – the size of a large squirrel – but would have dwarfed other early primates living then (*Palaeontology*, [doi.org/xmj](https://doi.org/10.1017/S0022267314000081)).

“The big surprise is a primate of such large body size that early in primate evolution,” says the study's corresponding author, Craig Scott of the Royal Tyrrell Museum in Alberta, Canada. Palaeontologists previously identified at least three species of *Purgatorius*, the earliest-known primate, which lived in North America around the same time. They were mouse-sized, like the majority of mammals in the age of dinosaurs.

Scott's new find, comprising teeth and jaw fragments, reveals a species with teeth twice the size and width of those of *Purgatorius*. The species, which he named *Ursolestes perpetior*, was between four and ten times the weight of a typical *Purgatorius*, making *Ursolestes* a giant among early primates.

“This find demonstrates that there is more variation in the size of the earliest primates than has been previously documented,” says Stephen Chester, from Brooklyn College in New York. So much diversity in the first million years of the Palaeocene suggests primates must have originated at the end of the Cretaceous period, shortly before the impact that wiped out the dinosaurs, says Richard Fox of the University of Alberta, co-author of the study. The identity of those primate ancestors remains a mystery, though he says they may have lived in upland areas, where fossils are rarely preserved. **Jeff Hecht ■**



Where it all came together?

Comet water is not like Earth's

#ROSETTAWATCH JACOB ARON

IF EARTH got its water from space, it probably wasn't delivered by comet. That's according to the latest data from the European Space Agency's Rosetta spacecraft, which has been analysing the water content of comet 67P/Churyumov-Gerasimenko and found it doesn't match the water on Earth.

The question of where Earth got its water – whether from asteroids, comets or in some other way – is a subject of ongoing debate. So analysing comet 67P's water was one of Rosetta's main goals. The spacecraft's ROSINA instrument has been sniffing the vapour around the comet ever since reaching it in August.

Kathrin Altwegg of the University of Bern in Switzerland and her colleagues have now analysed 67P's water, by looking at the amount of deuterium, a heavy isotope of hydrogen, and comparing it with the amount of regular hydrogen (*Science*, DOI: 10.1126/science.1261952).

"As soon as we got water from the comet, the pattern changed immediately," says Altwegg. The

comet's water has around three times as much deuterium as water on Earth, the researchers found. The ratio found on some other comets is much closer to that on Earth, suggesting a link between the icy space rocks and terrestrial water. The different composition of 67P's water suggests a more complex picture.

"We know there is material out there that has the signature of Earth's water in it, but is it the material that supplied it?" says Edwin Bergin of the University of Michigan, Ann Arbor, who previously found that comet Hartley 2 has similar water to that of Earth. Models of asteroid and comet motion within the solar system suggest asteroids were more likely to cross paths with Earth, but we don't yet know if they had the right mix of water to create the oceans. "We need many more measurements of this type to get an understanding of the

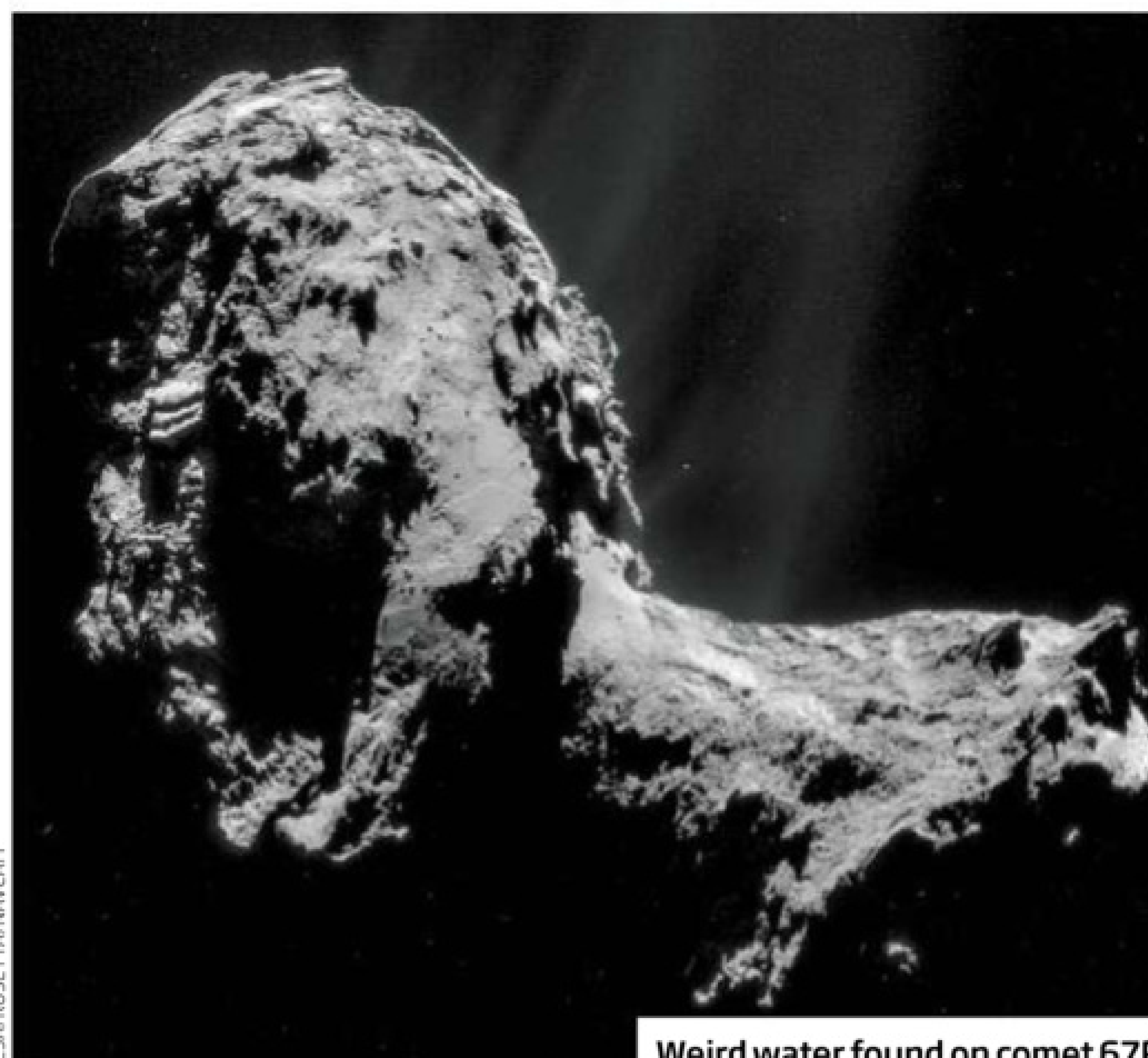
diversity within the population," Bergin says

"In the end, Earth's oceans are probably a mix of many things," says Altwegg.

The data collected so far may not be the last word on 67P's water. It is possible that there are pockets of water with a different deuterium-to-hydrogen ratio that could be released as the comet nears the sun and heats up. The two halves of the duck-shaped 67P might even have different hydrogen signatures, which would suggest they were once distinct bodies that formed in different parts of the solar system before colliding. "That would be a very interesting result," says Altwegg.

ROSINA's job has been made harder by the loss of Philae, the probe that landed on 67P in November but was unable to survive due to a lack of solar power. That could make signals of heavier molecules, particularly the amino acids necessary for life, more ambiguous.

"The identification of molecules is certainly more difficult," says Altwegg, who had hoped to compare ROSINA's data with Philae's Ptolemy instrument, which was designed to measure molecules in a different way. "If you have two different instruments you can resolve it, and this we cannot do, so it's all on ROSINA more or less." ■



Weird water found on comet 67P

Brain-zap effects depend on personality

ZAPPING your brain might make you better at maths tests – or worse. It depends how anxious you are about taking the test in the first place.

A recent surge of studies has shown that brain stimulation can make people more creative and better at maths, and can even improve memory, but these studies tend to neglect individual differences. Now,

Roi Cohen Kadosh at the University of Oxford and his colleagues have shown that brain stimulation can have completely opposite effects depending on your personality.

Previous research has shown that a type of non-invasive brain stimulation called transcranial direct current stimulation (tDCS) – which enhances brain activity using an electric current – can improve mathematical ability when applied to the dorsolateral prefrontal cortex, an area involved in regulating emotion. To test whether personality traits might affect this result, Kadosh's

team tried the technique on 25 people who find mental arithmetic highly stressful, and 20 people who do not.

They found that participants with high maths anxiety made correct responses more quickly and, after the test, showed lower levels of cortisol, an indicator of stress. On the other hand, individuals with low maths anxiety performed worse after tDCS (*Journal of Neuroscience*, DOI:

10.1523/jneurosci.3129-14.2014).

"It is hard to believe that all people would benefit similarly [from] brain stimulation," says Cohen Kadosh. He says that further research could shed light on how to optimise the technology and help to discover who is most likely to benefit from stimulation.

Sven Bestmann at University College London says the study is interesting but warns against making generalisations. "There may well be other variables that predict outcome better, so this is just the start," he says. Helen Thomson ■

"Participants with high maths anxiety made correct responses more quickly"



XINHUA/LI RAN/PA

Need more grass?

Wall of trees keeps deserts at bay in China

CHINA is holding back the desert, for now. The Great Green Wall – a massive belt of trees being planted across China’s arid north in what might be the largest ecological engineering project on the planet – seems to work, according to a new study.

“Vegetation has improved and dust storms have decreased significantly in the Great Green Wall region, compared with other areas,” says Minghong Tan of the Institute of Geographical Sciences and Natural Resource Research in Beijing. But whether planting trees is a long-term solution remains disputed.

The Gobi and Taklamakan deserts of northern China are Asia’s biggest dust bowls. Storms generated there regularly shroud Beijing in dust, which can also fall as far away as Greenland. In an effort to tame the deserts, in 1978 China began planting the wall, which is officially called the Three-North Shelterbelt Forest Programme. It is due for completion in 2050 and will eventually contain more than 100

billion trees in a 4500-kilometre belt, covering more than a tenth of the country. But opinion is divided about its success and advisability, and it has met with widespread scepticism among Western geographers.

Some credit a rise in rainfall for the decrease in dust storms across northern China over the past

“The wall will eventually contain more than 100 billion trees in a 4500-kilometre belt”

three decades. But Tan and co-author Xiubin Li say that their analysis of rainfall data, satellite images and an index of dust storms shows conclusively that the Green Wall is the main cause of the improvement (*Land Use Policy*, [doi.org/xk2](https://doi.org/10.1016/j.landusepol.2014.08.002)).

Away from the wall, vegetation cover and dust storms have risen and fallen with precipitation. But nearer to the trees, vegetation increased and dust storms diminished between 1981 and 1998, the end of the study period.

Tan says the improvement has since continued. “In most places in the study area, greenness continued to increase between 2000 and 2010,” he says. “In North China as a whole, we think the environment is getting well.”

There are exceptions, such as Minqin in Gansu province, where the Gobi and Taklamakan come close to meeting. “But these are small regions,” Tan says.

Two prominent critics of the Green Wall did not challenge the findings when spoken to by *New Scientist*, but warned that they do not tell the whole story. Hong Jiang of the University of Hawaii at Manoa, says China’s “aggressive attitude towards nature”, especially planting trees where they do not grow naturally, will not ultimately work. “Instead of controlling nature, we need to follow nature,” she says. Sometimes that means “allowing sand the freedom to roll”.

David Shankman of the University of Alabama in Tuscaloosa says it is not clear how permanent the Green Wall would be. “What is the mortality rate of planted trees? What happens when they die? And how do these trees affect grass and shrubs, which in general are more resistant to drought and more effective at erosion control?”

Tan agrees that the authorities should not just focus on increasing forests. “Grass may be better in most places in north China,” he says.

This viewpoint is echoed elsewhere. The African Union aims to tame the Sahara with a Great Green Wall of trees, but scientists from McGill University in Montreal, Canada, reported in October that grasses and shrubs would grow faster and be more useful (*Sustainability*, [doi.org/xk5](https://doi.org/10.3390/su5101811)).

More trees are still to come in China: last month the country announced that it will plant 1.3 billion trees along the Silk Road in partnership with the UN. **Fred Pearce** ■

Sun and Jupiter could detect cosmic ripples

RIPPLES in space-time could squeeze and stretch the sun and Jupiter, forming a gigantic gravitational-wave detector in our own celestial backyard.

Einstein’s theory of general relativity predicts the existence of space-time ripples – gravitational waves – but none have yet been detected directly. One way to find them might be by watching stars for vibrations caused by a passing gravitational wave, but these oscillations would be small compared with the star’s intrinsic fluctuations. Spotting similar signals in stars in the same cluster would help to distinguish waves from internal effects, but the nearest star clusters are too far away for existing instruments to check.

Closer to home, however, we have Jupiter and the sun, which are large enough and near enough to oscillate in concert. “Whatever happens to the sun due to gravitational waves, similar things must happen to Jupiter,” says Ibrahim Semiz of Bogaziçi University in Istanbul, Turkey. Studying the oscillations of the two together could help to detect gravitational waves, he suggests ([arxiv.org/1412.0992](https://arxiv.org/abs/1412.0992)).

Could we have already found them? Astronomers use a spectrometer called SYMPA to study Jupiter’s heaving surface, and several space-based instruments watch the sun’s oscillations. In 2011, SYMPA spotted Jovian oscillations that matched the sun’s in frequency to within 10 microhertz. Semiz speculates that the oscillations may have been due to gravitational waves.

Patrick Gaulme of New Mexico State University in Las Cruces, who is on the SYMPA team, points out that the error bars in their measurements are too high for such detections. “The signal we detected with SYMPA cannot be explained by gravitational waves,” he says. Nonetheless, he thinks the idea has merit. The trick would be to observe Jupiter and the sun over many days, so that any signal can rise above the noise. **Anil Ananthaswamy** ■



The Lepse: a floating Chernobyl

Danger - radioactive seabed

Debora MacKenzie

RUSSIA is finally going to demolish its “floating Chernobyl”, a ship full of highly radioactive waste from the Soviet Arctic fleet, 21 years after its existence was first revealed by *New Scientist*.

Even if it is dismantled safely, more dangerous radioactive junk lurks in the Kara Sea off north-west Russia, much of it unmapped and in the path of oil and gas exploration (see map).

The ex-Soviet ship Lepse contains 2.7×10^{16} becquerels of radioactivity – comparable to the caesium released by the 1986 Chernobyl accident. It comes from 638 fuel assemblies, submarine reactor parts containing spent fuel rods. Half are from the submarine Lenin, which lost reactor coolant in a 1966 accident, overheating and deforming the fuel so it could not be removed.

The European Union is worried that radioactivity will leak out and contaminate Arctic fishing grounds, and it offered to cut up the ship and remove its contents in 1994. But Russia resisted, possibly because it didn't want

foreign operators to learn that the uranium was more enriched than usual, says Nils Bøhmer of Norwegian environmental group Bellona, who took part in the negotiations. That would reveal how long the military subs could stay at sea without refuelling – more enriched fuel lasts longer.

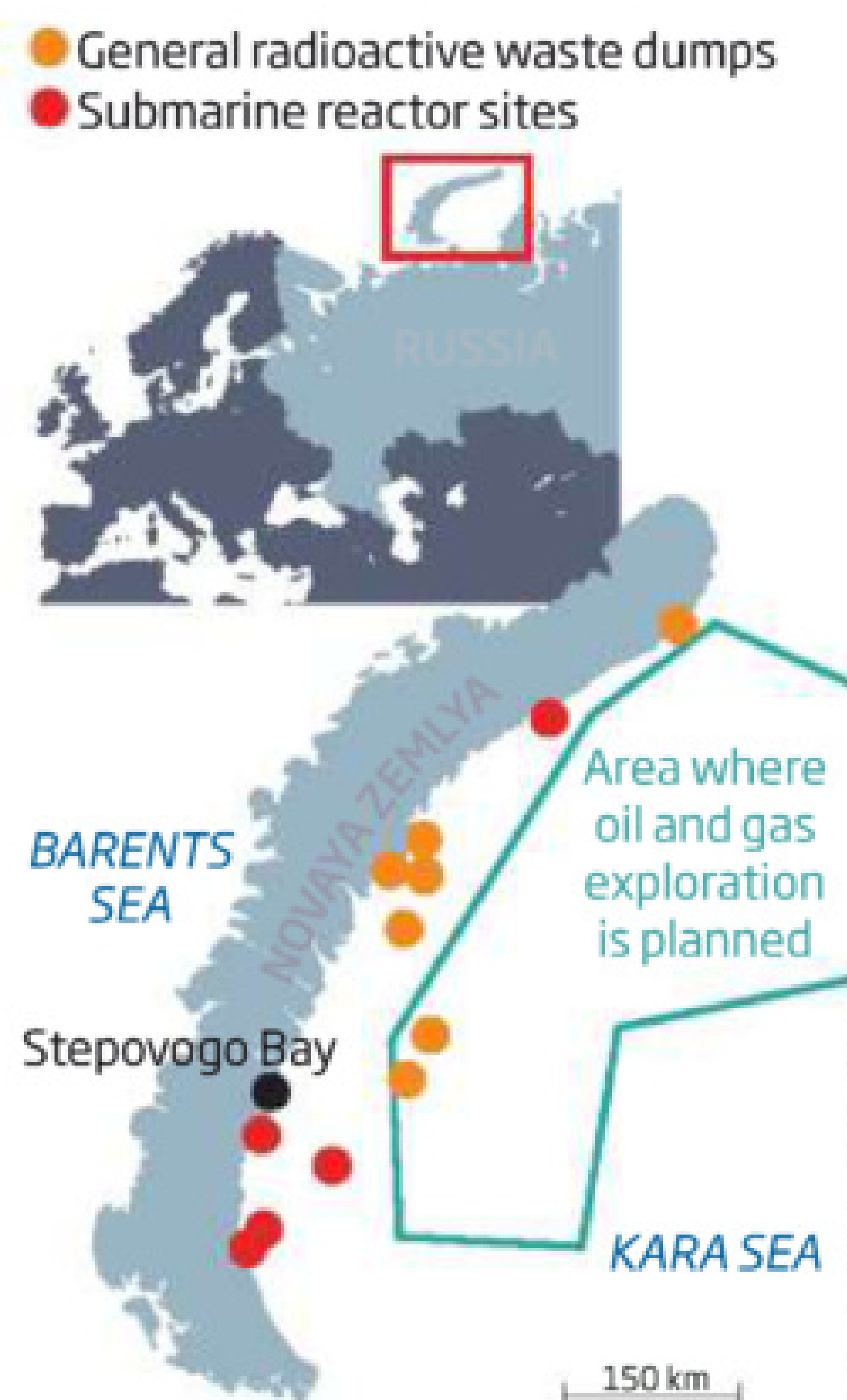
The Lepse was finally towed into dry dock in late October, and will be cut up using Russian technology starting this December, says Bøhmer. The midsection containing the fuel assemblies will be taken onto dry land for dismantling in 2016. “That is the most dangerous part,” says Bøhmer. “No one knows the condition of the fuel assemblies.” If one breaks and falls, the change in geometry could start a chain reaction. This would heat, melt and ignite the highly radioactive material. “It would be a real mess,” says Bøhmer.

Meanwhile, 16 whole submarine reactors dumped as waste by Russia still lie offshore, some complete with fuel. Two reactors are still in their subs. One sank in 2003 as it was towed to be

scrapped, and another was scuttled in 1981 after an accident. The two sunken subs alone account for “about half the radioactivity in spent nuclear fuel on the seabed in the Arctic”, says Per Strand of the Norwegian

Soviet nuclear relics

17,000 containers of radioactive waste and 16 submarine reactors dumped in the Kara Sea are a marine hazard



Radiation Protection Authority.

In 2015 Norway and Russia will release a scientific assessment on whether the two subs should be raised, but so far Russia has no plans to clear the rest of the sea's sunken radioactive hazards.

“No one knows the state of the fuel assemblies, if one breaks it could start a chain reaction”

Its own scientists, however, fear that severe contamination is imminent.

Strand took part in joint Russian-Norwegian surveys of the wrecks in 2012 and 2014, which found no radioactive leakage. But, he says, because saltwater will corrode the metal around the radioactive material, the “radioactivity from the spent nuclear fuel will eventually leak into the environment”. This could even happen by 2020, according to a September report by Valery Osminov of the Nuclear Safety Institute of the Russian Academy of Sciences. And given that the nearby facility for demolishing submarine reactors is due to close in 2020, the wrecks should be raised by then, he says.

Meanwhile, there are also 17,000 containers of solid radioactive waste sunk in the area. Recent surveys by Russia and the EU found only a little contamination in nearby sediments. But, says Osminov, 4000 were judged to be in poor shape and could corrode even faster. And unlike the sunken vessels and reactors, we know only roughly where the containers are – and some lie within an area where oil and gas companies plan to explore. “If oil drilling takes place and you hit one of the containers, you could release the radioactivity,” warns Bøhmer. “Unfortunately,” Strand says, “there are no concrete plans for raising the objects.” That is a Russian responsibility – but so far, says Bøhmer, no Russian ministry wants to take charge. ■

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CIARA PHELAN



Trick of the light makes bird feathers blue, but not red

LIKE the colour blue? You're not the only one. Blue jays and cardinals get their vivid hues in different ways, but for the same reasons. Efforts to understand why may help create coloured displays for devices like e-readers.

Colours in nature normally come from pigments, which absorb most light wavelengths, except for ones that they reflect to give the colour we see. But blue pigment is rare. Instead, the blue sported by bluebirds comes from tiny air pockets inside the feathers, which scatter light to create blue. Red feathers, however, rely on pigment alone.

Vinothan Manoharan at Harvard University and his

colleagues wondered if red colours were impossible to achieve without pigment. "We thought, maybe the birds know something we don't," he says. The team studied nanometer-scale plastic beads, an inverse version of the air pockets that give blue feathers their colour. Changing the size of the beads alters how light scattered from nearby beads interferes, enhancing particular shades.

Manoharan's team used large beads to try to enhance red light but, instead, purple appeared. The unexpected blue component appears for the same reason the sky is blue, Manoharan says: individual particles preferentially scatter blue light (*Physical Review E*, doi.org/xk7).

The group is now seeing if hollow beads can form reds, and hopes to use such "structural" colours in reflective displays that aren't backlit – think a Kindle, but in colour.

Brain links obesity with blood pressure

IS YOUR brain to blame for your high blood pressure? We've known for more than 30 years that fat and high blood pressure are linked, and at last we know this is thanks to the action of a hormone in the brain.

Leptin is produced by fat cells and normally makes a person feel full. But in people who are obese, the body stops responding to the message to stop eating, so leptin levels build.

The hormone was suspected of raising blood pressure in obese people via its effect on the sympathetic nervous system, which is involved in flight-or-fight responses. This network's action in the kidneys seems to raise blood pressure, but conclusive evidence of leptin's role has been hard to find.

Michael Cowley of Monash University in Melbourne,

Australia, and his colleagues have now shown that leptin is involved via its action in the brain. They have pinpointed an area in the mouse brain that increases blood pressure when exposed to high leptin levels (*Cell*, doi.org/xkr).

Turning to humans, the team found that obese people who either couldn't produce leptin or couldn't respond to leptin did not have high blood pressure – suggesting that leptin is indeed a linking factor.

Young, hot-headed stars could host life

STARS go through a fiery youth, burning up to 180 times as brightly as their mature counterparts. Planets orbiting such stars had therefore been neglected in the hunt for life – but they may be good hosts after all.

A planet is considered habitable when it is the right distance from its star to host liquid water on a rocky surface. Lisa Kaltenegger and Ramses Ramirez at Cornell University in Ithaca, New York, calculated that young, hot stars would have habitable zones further from the star than previously thought. The smallest and coolest stars can stay youthful for 2.5 billion years – which may be enough time for life to develop (arxiv.org/1412.1764).

"We call them 'infant Earths' because this will happen really early on in planetary evolution," Kaltenegger says. "It's a really simple idea but nobody seems to have ever thought about it."

Rocky rain brought lunar water

A RAIN of soggy space rocks may have brought water to the moon.

The moon is thought to have formed when a giant object smashed into the early Earth. The heat from this impact should have left the moon drier than a bone, so researchers were surprised to find water in rocks from deep below the lunar surface.

Erik Hauri at the Carnegie Institution of Washington and his colleagues analysed lunar rocks and estimate that meteorites equivalent to just 0.001 to 0.004 lunar masses could have brought water to the molten moon when it was 100 million years old (*Earth and Planetary Science Letters*, doi.org/xk6). "Anything that crashed into the moon at that point got mixed in wholesale," says Hauri.

Fiddler crabs jive to their own tune

FANS of *Strictly Come Dancing* look away now. Having a great sense of rhythm doesn't necessarily help you look attractive to the opposite sex. Fiddler crabs, as their musical moniker might suggest, have a great sense of timing. And they display it in synchronised dances that would make a choreographer proud. But it doesn't make them popular with female crabs.

Andrew Kahn of the Australian National University and his team put female banana fiddler crabs from a North Australian mangrove swamp into an arena full of robotic claws moving in various ways.

They found that maverick claws dancing to their own tune got twice as much attention from females as their conformist neighbours (*Animal Behaviour*, [doi.org/xh2](https://doi.org/10.1016/j.anbehav.2014.08.012)).

This means that crabs are probably not waving together on purpose, because animals are unlikely to evolve traits that make them sexually unattractive. Fiddlers are actually trying to make themselves the centre of attention - they just aren't very good at it.

"It's a really chaotic environment they live in and maybe they are just trying to follow a few basic rules that end up backfiring," says Luke Holman, one of the authors. "In a world where everyone is trying to be different, they all end up being exactly the same."



Nowhere to hide: electric eels use shocks to flush out prey

ZAP! Zap! Electric eels are well known for shocking their prey with 600-volt blasts. But the way they orchestrate their attack is more sophisticated than anyone thought.

It turns out the animals use one shock pattern to find their prey and another to paralyse it.

Eels in the wild emit a barrage of electric pulses into the water to disable nearby fish. To investigate, Kenneth Catania at Vanderbilt University in Nashville, Tennessee, placed fish in an eel tank and studied what happened to their

nervous systems and muscles as the eel electrocuted them.

Catania found that when the eel intended to disable the fish, the series of pulses was timed to precisely mimic the pattern of motor neuron signals that causes the animal's muscles to contract. Within 3 milliseconds, the signals effectively induced a full-body muscle spasm, paralyzing it completely (*Science*, [doi.org/xkq](https://doi.org/10.1126/science.1254444)).

He also discovered that the eel has another shocking strategy. If it can't see its prey, in murky water or rocky environments, for example,

it emits a different, high-voltage, two-pulse pattern. This makes the fish twitch uncontrollably, not only telling the eel that a snack is close at hand, but giving away its exact position. The eel can then move in for the final attack.

That eels evolved not only to disable but also flush out their prey is a surprise, says Jason Gallant at Michigan State University in East Lansing. "This is an immensely interesting and important finding for electric-fish biology." He wonders if other electrogenic fish do this, too.

Y men have a higher cancer risk

STILL smoking? If you're male, the habit might be costing you your Y chromosome - and raising your cancer risk.

Earlier this year, Jan Dumanski of Uppsala University in Sweden and his team found that men who had lost Y chromosomes from one-fifth or more of their blood cells had almost quadruple the risk of developing certain types of cancer. Now the team has linked some of those Y chromosome losses with smoking.

A study in 6000 Swedish men found that smokers were, on average, three times as likely as non-smokers to lose Y chromosomes from some of their blood cells. The result might help explain why men who smoke are on average between 1.5 and 2 times as likely as women who smoke to develop non-respiratory cancers (*Science*, [doi.org/xkz](https://doi.org/10.1126/science.1254444)).

The good news, however, is that Y chromosome levels in former smokers were the same as those in non-smokers. This suggests that the cells that retain Y chromosomes can return to dominance once men stop smoking. "The most important message is that this is reversible," says Dumanski.



Warm water found below Antarctic

NOT cool. The ongoing collapse of the West Antarctic ice sheet and the associated sea level rise may be happening faster than we thought.

Sunke Schmidt of the Helmholtz Centre for Ocean Research in Kiel, Germany, and his team combined a range of data sets on seawater properties at different locations and depths, going back to 1975.

They found that western Antarctica has recently seen warmer, saltier water being driven under the shelf - the part of the ice sheet that sticks out over the ocean (*Science*, [doi.org/xkx](https://doi.org/10.1126/science.1254444)). The warmer water

comes from the deep and is pushed up under the ice shelf by changing wind patterns.

This effect has never been incorporated into climate models used to predict future melting. That means the models will produce inaccurate sea-level predictions, says Schmidt. "They would likely underestimate them."

The results are "transformative", says Sarah Gille from the Scripps Institution of Oceanography in San Diego, California. They are a step towards making better climate-change projections.

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I am not robot

Google has a new hoop for you to jump through to prove you are not a bot, says **Hal Hodson**. And it is helping the firm to understand the web

GOOGLE updated its captchas on Wednesday. Those fuzzy words and blurred numbers that are simple for humans (in theory) to decipher and hard for bots, are there to guard websites, email services and social networks from automated attack. But they are also fuelling the development of artificial intelligence.

As spammers and their bots get ever better at breaking captchas, Google continues to make them harder – as anyone who has ever failed to decipher a mysterious swirl of lettering can attest. Alternatives, such as audio versions for people with a visual impairment, are less secure and often equally baffling.

The latest revamp fixes some of these problems, in part by doing away with the tests for recognised users. People that Google already knows are human can tick a box to affirm that “I’m not a robot” (see “Do I know you from somewhere?”). Those who aren’t automatically recognised can now pick matching images out of a grid – cats in a sea of dogs and hamsters, for instance.

Luis von Ahn, a computer scientist at Carnegie Mellon University in Pittsburgh, Pennsylvania, realised he could put our captcha-solving prowess to good use, and so find a silver lining to the internet’s bot problem. Instead of having us merely prove our humanness, Von Ahn designed the system to record and model that humanness and the intelligence behind it.

Von Ahn sold his technology to Google in 2009, and the internet giant has since improved on it,

building a software engine that teaches computers to recognise new things. As internet users verify their humanness, solving problems that only human minds can figure out, they build data sets that can be fed to algorithms. As well as reducing spam and blocking bots, Google’s system

“Captchas are turning the web into a training ground for AIs, helping them to recognise real objects”

uses the humans it protects to turn the web into training for AIs, with the goal of improving their ability to recognise real-world objects.

A team led by Dumitru Erhan at Google is working on a way to automatically caption pictures, and can already accurately add tags like “A group of people shopping at an outdoor market”, for example. Other research teams are on a similar path.

Roman Yampolskiy, a computer scientist at the University of Louisville in Kentucky says the information gathered through captchas has helped machine



Who's the bunny?

learning algorithms to reach their current state.

As humans tear through each new generation of captchas, the data they generate can teach machine learning algorithms to solve the same problems, giving computers a handle on more and more of the world. Yampolskiy and his graduate students are

working on a system that will allow any set of images on the internet to be used for captchas, enabling humans to train AI to tell different animals apart, or, say, tell cars from washing machines.

For the most part, data from captchas go to feed artificial neural networks, the computing systems that are inspired by the way the brain works.

Captcha’s evolution is evidence of the progress AI is making. The first puzzles can now be solved automatically by computers 99.8 per cent of the time, according to Google. Captchas are one of the most prominent human interfaces with this progress. Face recognition and search algorithms are improving behind the scenes, but mostly we are all stuck solving those annoying little tests, man and bot. ■

DO I KNOW YOU FROM SOMEWHERE?

How does Google know when to give real people a free pass on to a site, without cat categorising (see main story)? When it recognises them.

Google has what is probably the largest store of personal data on the planet. So it is fairly simple for the company to match its records up with incoming IP addresses and cookies – the small piece of code

that websites use to keep track of their visitors. So they can be pretty sure that the person trying to pass the captcha is human.

This has sparked some fears that Google is making it harder for non-Google users to prove their humanness around the rest of the web, as many services also use Google’s captchas.

Fight back against the hate

Online abuse seems to be getting worse, particularly against women, says **Aviva Rutkin**. But now regulators are taking a stand

"CAN'T wait to rape you." That's one of the anonymous messages sent earlier this year to Janelle Asselin, a comic-book editor and writer based in Los Angeles.

Asselin had written an article criticising the cover of the comic book *Teen Titans* #1. The response: a slew of tweets and comments from people questioning her credentials, calling her unprintable names and sending rape threats. "Most of the women I know with a solid online presence get them regularly. This is just a thing we are forced to deal with," Asselin later wrote in a blog post.

Asselin's story is not unusual. Concern over such online harassment has escalated in the wake of Gamergate, a movement that purports to call for better ethics in game journalism but has become known for ugly attacks aimed at its detractors.

Now, it seems, the problem might have finally peaked. Social-media companies, activist groups and even federal judges are rethinking how to best handle online abuse – and how to make internet users feel safe.

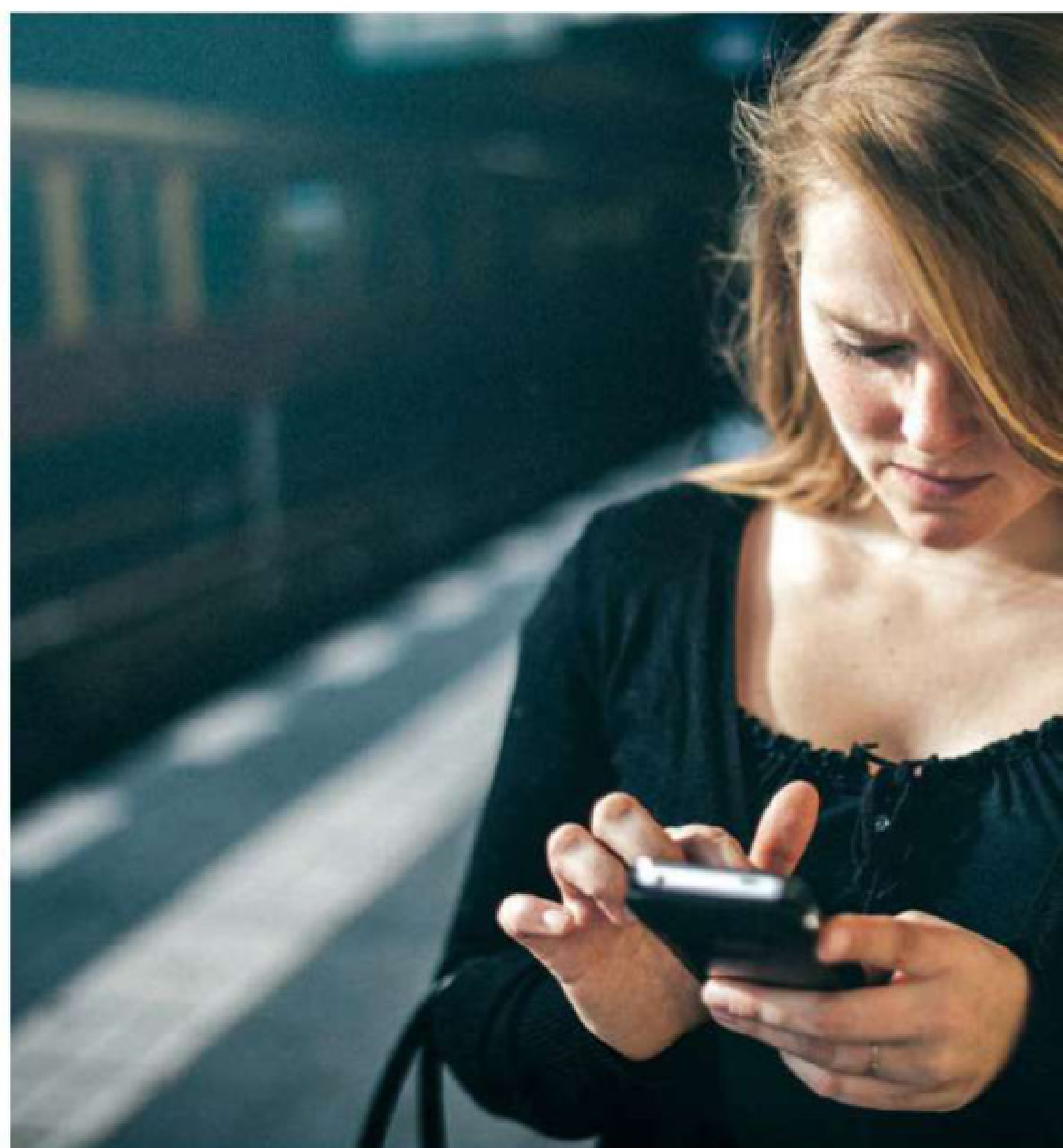
"The goal of these online mobs is to scare you enough to silence you," says Allyson Kapin, founder of online-marketing firm Rad Campaign and the Women Who Tech network in Washington DC. "People really want to see social networks step in and begin to take a stand against online harassment."

Twitter in particular has stepped up its game. In November

it teamed up with Women, Action, and the Media, a gender-justice group that will study how the company handles abuse problems and suggest possible improvements. And last week, the firm announced changes that will make it easier to flag problematic messages and accounts.

"Most of the women I know with a solid online presence get rape threats regularly"

Attention was drawn to the issue of social-media abuse this year by several high-profile cases: game developer Brianna Wu was forced to flee her home; feminist media critic Anita Sarkeesian was scared away from speaking at Utah State University over death threats; and actress Zelda Williams was driven to social-media silence after nasty messages about her father Robin



Williams's suicide.

But such harassment is not restricted to a few unlucky targets – a study by Pew Research released earlier this year revealed that 40 per cent of internet users have been harassed online. More than half said that they did not know the perpetrator, and 66 per cent said the most recent abuse occurred on social media,

rather than in emails, comment sections or online games.

Twitter's upcoming changes make it easier and faster to remove the harassers. Before, users had to fill out a nine-part questionnaire to report an offensive tweet; many of these questions have now been removed or streamlined. In addition, the company is

FIVE WAYS TO PROTECT YOURSELF ONLINE

If you are being threatened online, there are things you can do to protect yourself.

SAVE EVERYTHING Even if you would rather just delete the threats, it's important to save copies of everything. Those documents could help authorities to find and prosecute the offender.

REPORT THE ABUSE Most social-media sites offer users a way to report harassment. You can also file a complaint with the police or online at the Internet Crime

Complaint Center if you are in the US.

FILTER IT San Francisco engineer Randi Harper got fed up with negative reactions to a blog post she had written about her experiences with sexism and harassment. She built "Good Game Auto Blocker", which automatically finds Twitter users associated with Gamergate mobs and adds them to a block list.

HIRE A DETECTIVE If the situation gets really bad, firms such as Cyber Investigation Services in Tampa, Florida, specialise in

exposing anonymous harassers through psychological profiles, internet forensics and decoy websites.

TELL THEIR MUM Australian video-game journalist Alanah Pearce sometimes receives threats on her public Facebook page. When she realised that many of her trolls were just kids, she started tracking down their mothers' profiles and sending screenshots of the concerning messages. One shocked mum forced her son to send Pearce a



GUIDO MEI/GETTY

much, however: deleted accounts can be quickly replaced by new ones. And many police departments are unsure how to investigate internet threats or, worse, dismiss them as less serious than real-world threats. In her book *Hate Crimes in Cyberspace*, University of Maryland law

"Forty per cent of internet users have been harassed online. More than half did not know the perpetrator"

professor Danielle Citron argues that online harassment is a civil-rights issue that faces the same stigmas that stymied sexual-harassment cases in the 1970s.

Better police training could be a big help. At the College of Policing in the UK, a new internet-friendly curriculum will teach officers to take these reports more seriously and advise victims on how to collect evidence. Others have suggested equipping law-enforcement agencies with the spyware tools necessary to search for and ensnare offenders.

Some of the legal questions might be answered in *Elonis vs United States*, a case in which abusive comments made on Facebook by a man about his wife are being scrutinised by the US Supreme Court. Although the case does not directly address mob-like harassment, such as that directed against women by Gamergate, it could signify a shift in how US law defines free speech online.

While the court deliberates, private companies have an opportunity to be agents of change, says Mary Anne Franks, a law professor at the University of Miami in Florida. They are not required to enforce free speech, but can instead set their own rules for what is permissible on their platform.

"We have this tremendous potential at our disposal," Franks says. "A company like Google or Twitter or Facebook could easily revolutionise how we engage in discourse." ■

Reporting abuse is becoming easier

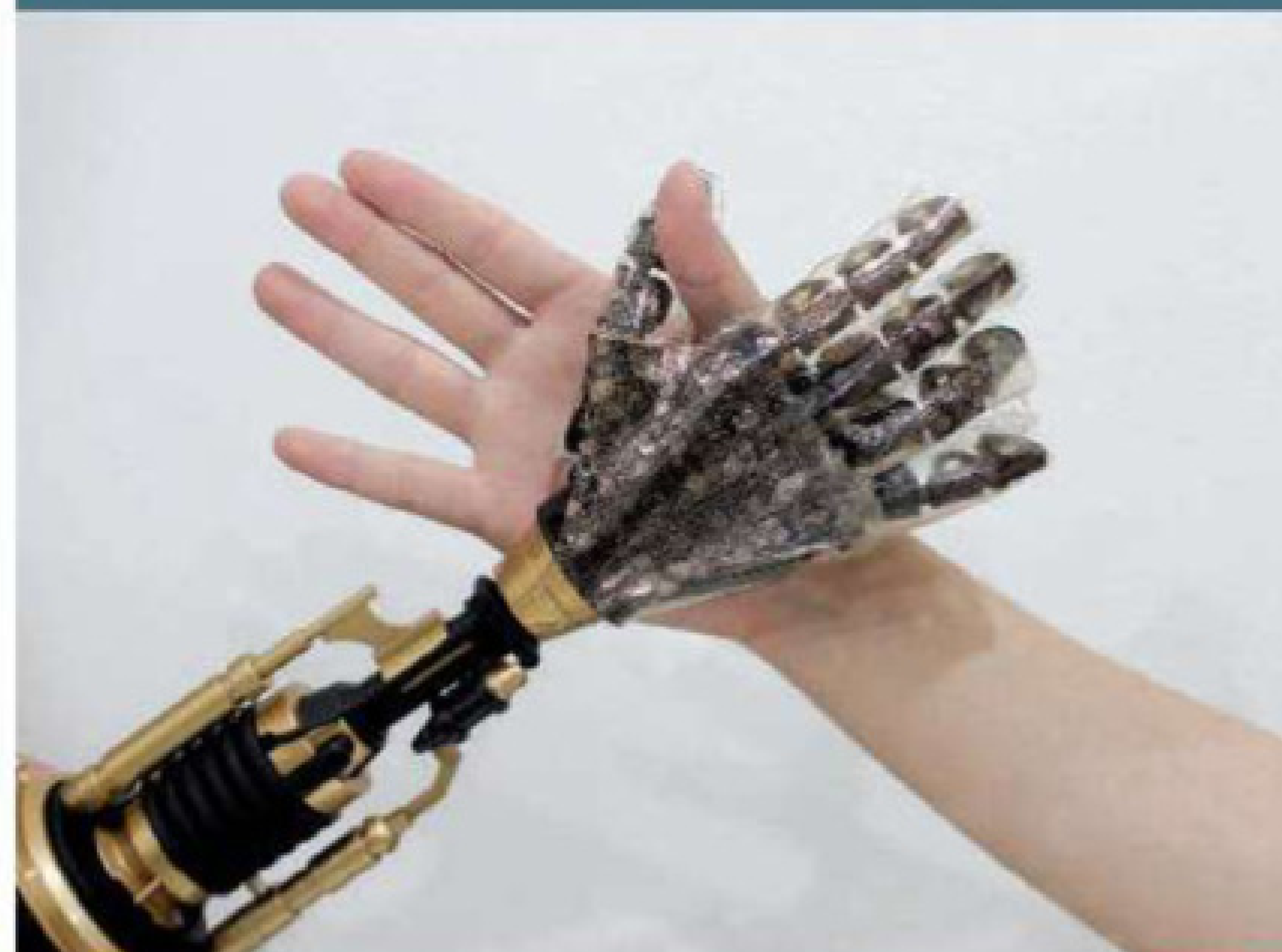
attempting to better tackle the sheer volume of complaints by prioritising tweets that are flagged by large groups of people.

Artificial intelligence could help, too. At the Massachusetts Institute of Technology, Karthik Dinakar has developed algorithms that can detect abusive speech in online comments. Such a program could feasibly be implemented in any of the major social networks. Dinakar suggests that software such as his could encourage users to rethink aggressive messages before they hit "send" by, for example, imposing a 30-second waiting period or by querying a potentially troublesome message ("Do you really want to say that to 600 followers?").

"People say things online that they would never say face-to-face or in person," says Dinakar. "We need better tools not just for monitoring, but also to tell people what good digital citizenry is all about."

Social networks can only do so

ONE PER CENT



Smart skin is just like the real thing

Technology is skin deep, thanks to a new synthetic material. The prosthetic smart skin is made of silicon nanoribbons and features pressure, humidity and temperature sensors. It also contains electrodes that could stimulate human nerves to deliver this information to the brain. The advantage of the skin, developed by Dae-Hyeong Kima and his team at Seoul National University in South Korea, is that it stretches, like human skin (*Nature Communications*, DOI: 10.1038/ncomms6747).

2,147,483,647

When South Korean pop star Psy's *Gangnam Style* music video reached this number of views, YouTube couldn't record any more. The website used 32-bit integers - strings of 1s and 0s that represent values - to record views, but this is the maximum that can be stored this way, so YouTube had to upgrade to 64-bit

Malaria test? They're phoning it in

Your phone knows if you're sick. IanXen, based in Indonesia, has developed a Malaria test using a microscope that clips onto an iPhone. The phone's camera analyses a blood sample through the microscope, after it has been treated with a diagnostic dye. The result can be sent to a central database. The firm has just started accepting pre-orders.

It's a good thing if your PC freezes

Future computers will be pretty chilled. The US intelligence research arm IARPA has tasked three major US technology companies with building super-cold supercomputers. Current computers all use silicon-based semiconducting chips, but these heat up when packed as densely as they are in a supercomputer. IBM, Raytheon BBN and Northrop Grumman will try to build cryogenically cooled superconducting chips, which will be far more efficient than standard computers.

DAE-HYEONG KIM

INSIGHT Online recruitment



CHINA/GETTY IMAGES

Job market of the past?

Network – minus the work

Think Amazon suggestions, but for jobs, says **Rachel Nuwer**

MAYBE you read *Gone Girl* because Amazon recommended it; watched *Breaking Bad* because Netflix suggested you'd like it; even met the love of your life because OKCupid said you'd get along. But you probably had to rely on traditional methods when it came to landing your job.

Several start-ups are aiming to change that. They want to replace career fairs and classifieds with online systems. While LinkedIn is still the behemoth of such networking, these start-ups are unique in tailoring services to specific cohorts, ranging from students to hourly wage earners.

Collegefeed, launched in 2013, was built with recent graduates in mind. Profiles emphasise personality and motivation over real-world experience – which most students lack. The site's algorithms then provide jobseekers and employers with suggestions for potential matches.

"Many students and professionals are already actively engaged in creating and maintaining online profiles, and these start-ups build on that," says Melissa Venable at the US National Career Development Association near Charleston, South Carolina. "As the systems become

more sophisticated, they could evolve into the future career fair."

Sanjeev Agrawa, Collegefeed's founder and CEO, agrees. Online systems, he says, mean employers aren't limited to career fairs at a handful of top colleges: they can connect with students everywhere. Some 40,000 students and 800 employers in the US and Canada have signed up to Collegefeed, and Agrawa says that around 50 per cent of students make contact with

"As the systems become more sophisticated, they could evolve into the future career fair"

employers. "The [US] national average for getting connected with a job you apply for is 5 to 8 per cent," he says.

Another service, ZippyApp, is aimed at jobs that pay by the hour – in restaurants or retail, for instance. Turnover is high in this sector, so hiring can eat up time. ZippyApp sorts applicants based on experience, availability, skill set and more, and then ranks matches for a given opening. Once a connection is made, success rates are as high as 80 per cent, says

Kamyar Faron, ZippyApp's founder.

Faron is extending the idea to mid-career professionals with a site called Talentral. "A LinkedIn profile helps for being found, but not for sending different sales pitches to different people," says Faron. His service allows people to make unlimited profiles, each tailored to different companies. Algorithms add tags that help these appear in relevant searches.

How effective are such algorithms? Netflix has spent big to make sure its suggestions come from a range of genres – will the employment equivalent be as sophisticated? Or will it echo offline recruitment, only connecting employers with candidates from leading colleges, and employees with high-profile companies?

Faron says ZippyApp's algorithm is dynamic, so it improves with every new user and connection. "It learns as more data becomes available."

These services are not yet perfect. Just as people who share a favourite colour aren't guaranteed to fall in love, neither is someone with the right skill set necessarily a good fit for a certain company. But as the technology improves, finding an ideal job may one day be as easy as picking a TV show. ■

Your camera shake can give you away

HERE's a way to shake off anonymity – literally. Footage from wearable cameras contains a "motion signature" unique to you. The discovery could identify police wearing body cameras, but also let authorities single out protesters uploading footage, say.

Shmuel Peleg and Yedid Hoshen at Israel's Hebrew University of Jerusalem collected footage from 34 people who wore GoPro cameras on baseball caps. They ran it through an algorithm that recognised motion signatures particular to each person.

This was achieved by dividing frames into non-overlapping blocks. Movement of these blocks between frames reveals the vertical and lateral motion of the camera. When videos were analysed, the system accurately identified from the movement alone who was wearing the camera 88 per cent of the time. Just 12 seconds of video were needed to make the identification (arxiv.org/abs/1411.7591).

"People who upload videos to the web may not be as anonymous as they think they are," says Peleg. "On the other hand, if police officers have to wear cameras, this may give another level of assurance that the video you are being shown is from that officer and not someone else. It's a double-edged sword."

Chris Baraniuk ■



METROPOLITAN POLICE/PA

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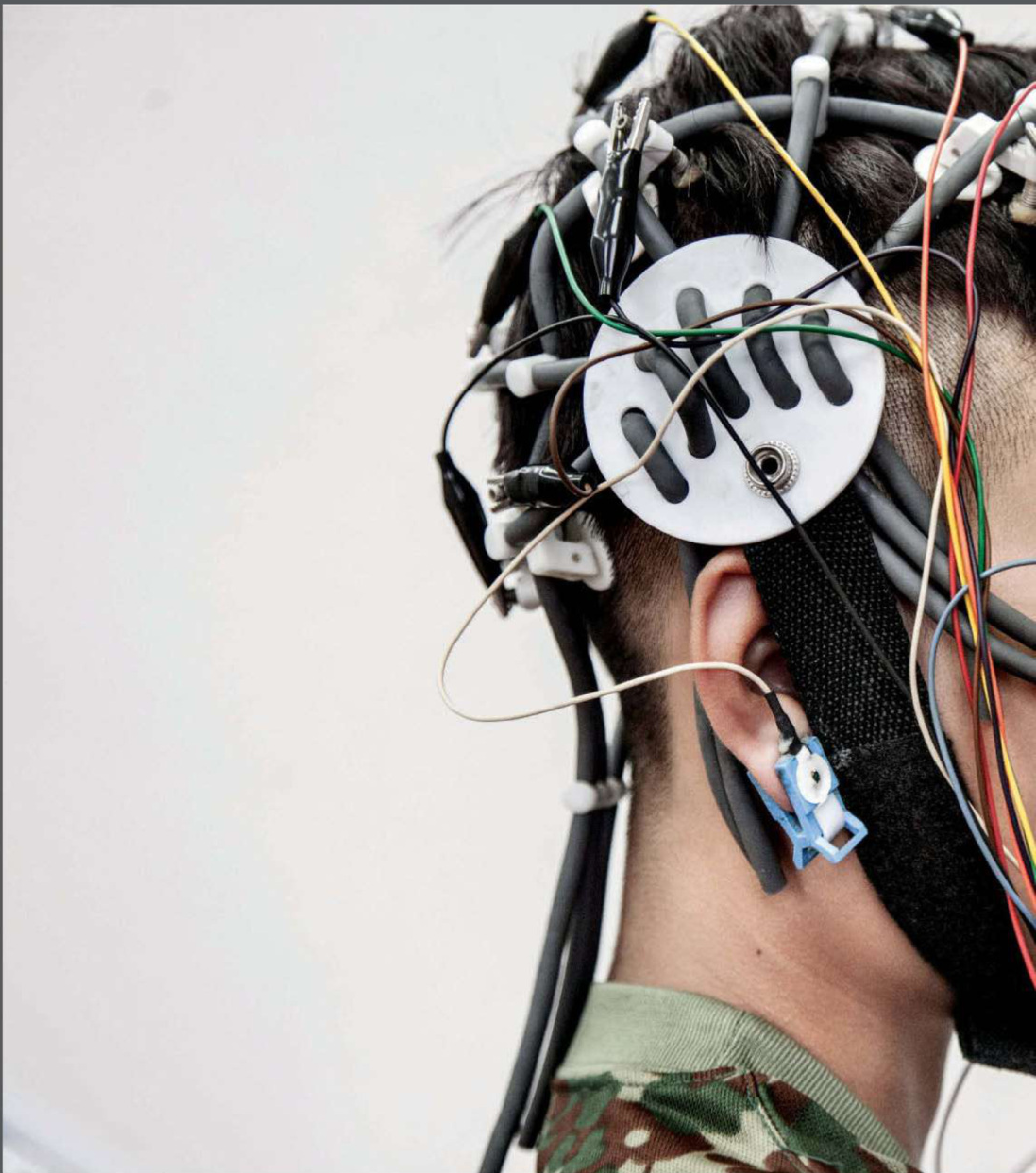
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Hooked on the web

IN CHINA, if you are a kid who spends a long time online, you had better watch out. Your parents may send you off for “treatment”.

At the Internet Addiction Treatment Centre in Beijing, children must take part in military-style activities, including exercise drills and the singing of patriotic songs. They are denied access to the internet. One of the first experiences internees undergo is brain monitoring through electroencephalography (EEG). The programme is run by psychologist Tao Ran, who claims the brains of internet and heroin addicts display similarities.

The rise of such centres has, in some cases, been coupled with reports of brutality. One camp in Henan province was recently criticised after it was alleged that a 19-year-old girl died following corporal punishment doled out by officers.

These photographs were taken by Fernando Morales during a four-day visit to the Beijing centre in June with journalist Zigor Aldama.

“We had heard stories about electroshocks, physical torture and confinement, but we found none of those,” says Aldama.

“The children usually get angry when they know that they’ll be locked in the centre, where parents put them without prior notice. They deny suffering an addiction. But as time goes by, I believe they are more sociable and calm. They get in better physical shape thanks to the sports training,” Aldama says. Chris Baraniuk



Photographer

Fernando Morales Panos Pictures

Welcome to the club

Some social species have culture. Great, but that means we have to think harder about how we conserve them, says **Philippa Brakes**

SOMETHING momentous happened in conservation circles last month in Ecuador. At the UN Convention on Migratory Species conference, a resolution was passed recognising that some social mammals have culture.

Sure, the idea of non-human culture has been around for years. But this is the first time that it has been formally recognised by an international treaty. And beyond acknowledging that it isn't just humans that have socially learned traditions, this treaty opens up a new frontier for efforts to conserve social species.

What is non-human culture? A popular definition is information or behaviour – shared by a population or subpopulation – acquired from others of the same species via social learning. What this means for conservation, which often treats a species as homogeneous, is that culture can



create boundaries between social groups, affecting behaviour, gene flow and resource use.

In 1975 sociobiologist E. O. Wilson noted the influence of social structure on fitness, gene flow and spatial patterns in some species. Deeper understanding only started to emerge in the past decade, and wildlife policy has been slow to catch up.

The new resolution recognises both positive and negative consequences of non-human culture. Individuals passing on knowledge may increase population viability by allowing the rapid spread of innovations amid environmental challenges, which could mean more-resilient social groups. On the other hand, the effects of human-induced threats may be amplified by the presence of non-human culture.

How so? The type of threat and the type of society is important.

No need to ban 3D

There is no evidence of harm from new viewing technologies, says **Martin Banks**

CHILDREN aged under 6 should be stopped from using stereoscopic technology such as 3D movies, computers and video games, says France's health and safety agency, ANSES. It also says children below the age of 13 should use the technology in moderation.

The call, which follows similar recommendations by the agency's

Italian counterpart last year, cites a new analysis of research into possible effects of 3D viewing on a child's developing visual system.

Crucially, the agency's report is unclear about what exactly this new analysis is. However, what is clear is that there is no published research, new or old, that shows adverse effects of watching 3D

content other than short-term discomfort that can affect children and adults alike. There are no reports of long-term harmful effects at any age, despite years of use of the technology.

Why might 3D viewing raise concerns? The human visual system changes significantly during infancy, particularly brain circuits involved in perceiving the enhanced depth associated with 3D technology. Development slows during early childhood, but it

"There is no 'smoking gun' to suggest harm is being caused, and any ban looks overly harsh"

still changes in subtle ways into adolescence. The visual experience of an infant or young child also affects the development of these binocular circuits (*Science*, DOI: 10/ctvk2c). So careful monitoring of how new technology affects young children is understandable.

At the heart of the concerns is a well-studied effect of 3D viewing technology. You have to direct both eyes at images that appear to be in front of or behind the screen while at the same time focusing on the source of the image, the screen itself – an unnatural state of affairs. The first action is called vergence and the second is known

For example, orca societies are often conservative and so may be reluctant to adopt an innovation in response to a new threat, like the depletion of a food source. The distinct cultures of different groups also lead orcas to behave in different ways, and this can make one group more vulnerable than another. So they should be assessed as cultural groups, rather than by absolute population numbers.

In African elephants, older matriarchs are thought to act as “repositories of social knowledge”, holding information important to the survival and fitness of their social group, such as the location of food or water. Their removal may have impacts beyond the loss of one elephant.

There is also evidence that baleen whale calves learn migratory routes from their mothers and that hunting two species – southern right and humpback whales – meant that critical knowledge was lost.

Official recognition of non-human culture is welcome, but it is only the first step. The challenge now is to ensure conservation practice reflects the science. ■

Philippa Brakes is senior biologist at the charity Whale and Dolphin Conservation (whales.org)

as accommodation, with 3D viewing causing vergence-accommodation conflict. Discomfort can result, more in some people than others. The feeling seems to dissipate when viewing stops.

While we might not know all the consequences of 3D viewing at different ages, there is no “smoking gun” to suggest it’s harmful. And although it’s prudent to be alert to health risks, a ban for young children would be unnecessarily harsh. ■

Martin Banks is professor of Vision Science at the University of California, Berkeley

ONE MINUTE INTERVIEW

Beyond the imitation game

It’s time to put creativity centre stage when thinking about computer smarts, says artificial-intelligence expert **Mark Riedl**



PROFILE

Mark Riedl is an associate professor at Georgia Tech’s School of Interactive Computing in Atlanta. His work straddles artificial intelligence, virtual worlds and storytelling. He has developed a new form of the Turing test, called the Lovelace 2.0 test

notion that if you want to look at human-like capabilities in AI, you mustn’t forget that humans create things, and that requires intelligence. So creativity became a proxy for intelligence. The researchers who developed that test proposed that an AI can be asked to create something – a story or poem, say – and the test would be passed only if the AI’s programmer could not explain how it came up with its answer. The problem is, I’m not sure that the test actually works because it’s very unlikely that the programmer couldn’t work out how their AI created something.

How is your Lovelace 2.0 test different?

In my test, we have a human judge sitting at a computer. They know they’re interacting with an AI, and they give it a task with two components. First, they ask for a creative artefact such as a story, poem or picture. And secondly, they provide a criterion. For example: “Tell me a story about a cat that saves the day”; or “Draw me a picture of a man holding a penguin.”

Must the artefacts be aesthetically pleasing?

Not necessarily. I didn’t want to conflate intelligence with skill: the average human can play Pictionary but can’t produce a Picasso. So we shouldn’t demand super-intelligence from our AIs.

What happens after the AI presents the artefact?

If the judge is satisfied with the result, they make another, more difficult, request. This goes on until the AI is judged to have failed a task, or the judge is satisfied that it has demonstrated sufficient intelligence. The multiple rounds means you get a score as opposed to a pass or fail. And we can record a judge’s various requests so that they can be tested against many different AIs.

So your test is more of an AI comparison tool?

Exactly. I’d hate to make a definitive prediction of what it will take for an AI to achieve human-like intelligence. That’s a dangerous sort of thing to say.

Interview by Sean O’Neill

What are the elements of the Turing test?

The Turing test was a thought experiment that suggested if someone can’t tell the difference between a human and a computer when communicating with them using just text chat or something similar, then whatever they’re chatting with must be intelligent. When Alan Turing wrote his seminal paper on the topic in 1950, he wasn’t proposing that the test should actually be run. He was trying to convince people that it might be possible for computers to have human-like abilities, but he had a hard time defining what intelligence was.

Why do you think the test needs upgrading?

It has been beaten at least three times now by chatbots, which almost every AI researcher will tell you they don’t think are very intelligent.

A 2001 test called the Lovelace test tried to address this, right?

Yes. That test, named after the 19th-century mathematician Ada Lovelace, was based on the

Print a virus to kill the cancer

It shouldn't take years and a billion dollars to create a new cancer drug. Biohacker **Andrew Hessel** aims to do it in a day

You worked in big pharma. Why did you leave?

More than a decade ago, I was with a large biopharma company where I learned first-hand that drug development wasn't really working. Putting tremendous resources into R&D didn't necessarily produce a lot of results, even though we used the most advanced genetic technologies and the best people. I decided to re-evaluate my career, and spent a year on the beach in Thailand thinking about what to do next.

Did inspiration hit you regarding a better way to make drugs?

I had seen technology for printing DNA as far back as 1998 and I thought "this is the answer", because it meant you didn't need to be in a lab to do genetic engineering. You can do the design on computers – something I was very familiar with in bioinformatics – and then print the DNA.

In 2004, I focused on synthetic biology, and in 2009 founded the first cooperative biotech company, Pink Army Cooperative.

It's really about making a specific medicine tailored to one person – "N-of-1" medicine – rather than trying to make it a best fit for a whole population. My vision is to create a personalised treatment that can be made in a day by printing bespoke cancer-fighting viruses. We want to get some of the world's best virologists taking part in the design process, so we have made it open source. It's within reach of any scientist that wants to try it in their own labs.

That's a very ambitious vision, isn't it?

I've never claimed that these technologies will be able to cure anyone first off. The aim is to demonstrate that you can sit at a laptop and

design a virus that you believe will infect and kill specific cancer cells, have that virus printed, and test it in culture, all for a few hundred dollars. It is a revolutionary idea for people who think it costs a billion dollars to build a personalised drug... or any drug.

Is that feasible with the state of technology?

In 2012 I joined Autodesk, based in San Rafael, California, which focuses on software design. At that time, the DNA-synthesis firms out there could not routinely print even the smallest viral genomes. But by the end of 2013, some of

"I never want to sell a drug. I see the business model as something like Netflix"

these firms were calling me back saying they could do it. What we're seeing is just the start of being able to make more and more virus particles really inexpensively. So the question now is how do we put together this whole pipeline to design, build and test cancer drugs?

Why focus on cancer-fighting viruses?

For lots of reasons. For me, they are the best examples of inexpensive programmable drugs. And they can hack a cancer cell and turn it into a virus-manufacturing plant, so you only need a very small amount of virus to act as a seed.

The focus also has to be on something we can design and customise easily using software. A virus is not dumb like a chemical, which does one job. A virus has logic mechanisms and switches, so they are very tunable and programmable: in viral engineering, you can actually build

combinations of segments of code into your design. We also need to be able to print these viruses using DNA printers, so it's useful that they have only a small amount of DNA. Finally, there is a very long history of oncolytic – cancer-fighting – viruses being used in R&D.

Have such viruses been successfully used?

There were no good anecdotal cases of oncolytic virus use until a few years ago. One of the first I saw was the case of Emily Whitehead, who as a 6-year-old had horrific childhood leukaemia that was treated using an engineered HIV virus (modified so it couldn't cause disease) that reprogrammed her immune cells to fight off her cancer. That was a dramatic success.

And earlier this year, the Mayo Clinic published a paper on two people with multiple myeloma. The researchers used a modified measles virus and showed that it perfectly targeted the cancer in both patients. These cancers were resistant to other treatments, and one patient went into full remission after one viral treatment. These types of case are what you'd expect from N-of-1 treatments. They are the beacons for ongoing development.

Once you have the DNA-printing technology up and running, what happens?

I'm going to build and test this in three stages. Once the technical foundation is in place, we'll take some cancer cells in culture and open up the software for researchers to design a cancer-fighting virus and test it against those cells. Step two is doing this in cats and dogs. There is already a large field of oncolytics in veterinary science, but it's mainly palliative and such processes have as many side effects in dogs and cats as in humans because vets are really just repurposing human therapies. If we can



PROFILE

Biohacker Andrew Hessel founded the Pink Army Cooperative, an open-source drug company. He is also a distinguished researcher in the Bio/Nano/Programmable Matter group at software firm Autodesk, based in San Rafael, California

prove the technology in the animal model, it will provide the foundation for the third step – starting work with humans.

What about regulatory hurdles for personalised cancer treatments with no clinical trials?

The question I always get is what am I going to do about the US Food and Drug Administration? But when you're working with *N-of-1* medicines, regulatory concerns are the last of your worries. Really you make the drug for the individual, so at the end of the day it's the individual who has to choose whether to take it or not. You're always going to be working with someone who has no other pharmaceutical options, and the FDA has allowed such "compassionate use" in similar cases.

How much will your treatments cost?

I want *N-of-1* treatments for humans to be free. I never want to sell a drug. I see the business model shifting away from the blockbuster-drug model of the pharma industry – getting the best product for the most people and charging the most for it – to more of a Netflix model, in which you might purchase a subscription for all-that-you-need medicines to manage your cancer. So I see the designs for human cancer treatments, maybe even the designs of other disease treatments, being very nearly free.

How will that be sustainable?

Let's just say this: if the digital pathway is robust, I'm pretty sure I can get the virus-printing costs down to a dollar a dose. The virus itself is designed by algorithms using diagnostic data from the patient. That info is put into a program that will design the cancer-fighting virus, so the cost of design is cheap. Then there's testing, and there is no simpler test than on the patient's own cancer cells in a dish. So that whole process should cost less than \$100 end-to-end. If you are on a cancer-subscription model paying \$100 a month, I see that as ultimately profitable.

You're clearly not in it for the money...

If I wanted to make money tomorrow, there are other areas of virus engineering that have a much lower bar because they don't deal with human therapeutics. But as the tech platform develops and we start treating animals and doing *N-of-1* studies, the mindset will change and then no one will ever again be able to charge a billion dollars to go and make a cancer drug. ■

SIMON KUO

Interview by Catherine de Lange

Wrong the right way

From Bill Johns

John Ioannidis risks doing more harm than good in driving out scientific papers that are wrong (22 November, p 32). The sort of multiple checking he recommends makes it more difficult for individuals and authors from small, poorly funded institutions to get their ideas heard.

Large institutions tend to develop a momentum that makes them less likely to come up with really radical ideas than those less-fashionable centres may produce. Of course, these radical ideas are more likely to be wrong.

The answer lies with university appointment panels and grant-awarding bodies. These give researchers an incentive to submit as many publications as possible and get the most radical ideas out early (when they are still half-baked).

If both bodies demanded that applications should be backed by no more than six papers, researchers would have an incentive to minimise their number of publications with better integrated, related work and better tested ideas in their more important papers.

Making appointments and giving grants is expensive; it would be worth getting paid referees to re-review all six papers submitted in each case. *Reading, Berkshire, UK*

From Ted Lovesey

Ten years ago, Ioannidis identified wide-ranging problems with scientific research, but this is not a new phenomenon. Studies of aircrew fatigue during the second world war had little success in quantifying the origins of poor performance, until cognitive psychologist Frederick Bartlett realised that piecemeal studies were inappropriate and all relevant factors are needed to produce sensible results.

Somewhere along the way

Bartlett's message has been lost. Most researchers have been trained to limit the variables in an experiment so that statistics are manageable and correlations can be made. This makes life easier but means that some important factors are omitted that could have had a major influence upon the results.

Perhaps we should be critical of the way in which experimental design is taught.

Stoke Gabriel, Devon, UK

Rampant robots

From B. M. Evans

Chris Baraniuk's article on robotic warfare was thought-provoking, but there is an additional aspect of warfare that was not considered (15 November, p 38).



In a democracy, governments' zeal for warfare requires a considerable measure of public support, and there is nothing like a procession of returning body bags to turn the public against a war. We have experienced this recently in the UK over the war in Afghanistan.

In a robotic war, the more technologically advanced combatant can expect few casualties as long as ground troops are not used extensively.

Consequently, the public will have little information regarding the progress and extent of the engagements, and arguably will have less interest than in conventional wars.

This means that politicians will

be freer to wage war abroad than they are now. This is not a welcome prospect.

Feniton, Devon, UK

From Michael Berkson

Before embarking on the development of lethal autonomous weapons systems, we should bear in mind Walter M. Miller's 1954 science fiction short story *I Made You*. It is narrated from the viewpoint of a heavily armed, robot tank. Battle damage has destroyed the tank's capability to identify friend from foe. It therefore bypasses all the built-in safeguards and systematically annihilates its own creators.

Great Shelford, Cambridgeshire, UK

Dammed floods

From Michael Hope

I read with interest Peter Hadfield's article on the Yangtze river (22 November, p 46), having returned in September from a cruise down the river from Chongqing to Shanghai, including a tour of the Three Gorges dam and journeying through the five ship locks.

An important function of the dam that was not mentioned is to control flooding, which is a major problem for the seasonal river of the Yangtze.

Millions of people live downstream of the dam, with many large, important cities like Wuhan, Nanjing and Shanghai situated adjacent to the river. Plenty of farm land and China's most important industrial area are built beside the river.

The Yangtze has seen some terrible floods. In 1931 there were 145,000 deaths although some Western sources put it much higher, between 3.7 and 4 million.

Further flooding killed 33,000 in 1954 and in 1998, 15 million were made homeless and the economic loss was estimated at over £16 billion.

Ambleside, Cumbria, UK

The editor writes:

■ Hadfield notes that some of the most serious flooding along the Yangtze is generated downstream of the dam, and there is a debate about whether the dam will be a blessing or a curse in terms of flooding. Sadly there was no room to include this in the article.

Discount vaping

From Alan Wells

You discuss the problem of e-cigarettes possibly becoming a gateway to smoking (1 November, p 35). This could surely be solved by pricing policy.

Simply structure sales taxes to make e-cigarettes relatively cheap and readily available, and cigarettes and other forms of tobacco prohibitively expensive.

Of course, this would involve countries not entering into deals such as the Trans-Pacific Partnership (TPP), which affects New Zealand and Australia, and the Transatlantic Trade and Investment Partnership (TTIP), which could considerably constrain the ability of sovereign governments to make such laws (1 November, p 32).

Wellington, New Zealand

Hold the mayo

From Miriam Heppell

I was rather surprised to read of a new eco-friendly egg-free mayonnaise, and the intensive research required to find a plant ingredient to take the place of egg (22 November, p 31).

Almost 20 years ago, when diagnosed with an egg allergy, I began buying a similar vegan product made using pea protein.

This product is still available, is very similar in texture to standard mayonnaise and is quite delicious. I stopped eating it because of the rather unsociable effects of the pea protein.

As an alternative, I now simply whip up plain yogurt with a little

olive oil, crushed garlic, black pepper and cider vinegar.
Basildon, Essex, UK

Credibility denial

From Simon Dunkley
Your article reporting the acquittal of six geologists sentenced to prison for allegedly downplaying the risk of an earthquake (15 November, p 7) quotes the head of Italy's National Institute of Geophysics and Volcanology saying the ruling "restores credibility to Italy's scientific community". Surely that should have read, "restores credibility to Italy's legal system"?
Pulborough, West Sussex, UK

A thousand words

From Rian Hughes
Pamela Protheroe writes that children read slower when pictures are present (29 November, p 32).

But the reason children read more slowly when pictures are present is that they are dividing their time between reading the text and looking at the pictures, which is the whole point of picture books.



One might as well say that pictures with distracting text beside them lead people to study the pictures less closely.

An unstated bias that words are more valuable than pictures relegates art books, comics and other books with a strong

illustrated element to second-class status.

As a professional comics artist, I have met several literate and intelligent adults who cheerfully admit that they can't "read" comics, or find analysis of a picture confusing without an accompanying linear textual explanation, which leads me to think the education system may be missing something.
Kew, UK

Bat battles

From Ian Rabjohns
You report on bats intentionally jamming each other's sonar when several are feeding in the same locality (15 November, p 16). While recording bat species in the Wye valley area near south Wales I regularly picked up several common pipistrelles (*Pipistrellus pipistrellus*) feeding together.

Each individual made a slight shift in frequency from the standard 47 kHz. Every now and then I would get what I termed the "sod off" call – a very loud broadband "shout" covering the whole frequency range and much more at either end.

I always presumed that this was to discourage the opposition from coming too close to the bat concerned or to its prospective meal. It would also interfere with the reception of any other bat nearby; it certainly gave me a shock if I was close enough and wearing headphones.

Penallt, Monmouthshire, UK

Snack attack

From Keith Roy
You report that seals have been recorded attacking porpoises, and the issue immediately brings one idea to mind (29 November, p 7).

Porpoises and seals share almost identical diets and we are currently wiping out their food supply. Is it any wonder they are fighting over a dwindling resource

that is essential to both?

It's probably a good thing that neither of them have the means to attack fishing boats!
Stockport, UK

The editor writes:

■ The seals appear to be actively hunting porpoises, particularly young calves, so it's possible the seals have broadened their diet after traditional food sources became scarce.

Sailing away

From Douglas Dwyer
Further to the discussion of what civilisation would look like without fossil fuels (18 October, p 34), we forget that for the last 200 years fossil fuels were chiefly employed to offset energy lost to friction, later recouped through efficiencies such as regenerative braking.

Ocean transport ignores the implications of friction by employing heavy fuel oil no one else will use, in a place where legal restrictions are lax. With proper laws and recognition, seasonal trade and sail could return and become the most efficient means of transport of all.

Cairanne, France

Wings of speed

From David Coker
E. H. Bristol questions the reported 2200 kilometre flight in two days by a banded stilt (22 November, p 35). The original paper reports that the bird flew "a minimum of 2263 kilometres in 55.9 hours", which works out at an average speed of just over 40 kilometres per hour (*Biology Letters*, doi.org/wnv).

An earlier project tracked the migration of the bar-tailed godwit from Alaska to New Zealand (bit.ly/ns-godwit). Aided by tailwinds, one bird flew 11,000 km in just over eight days, averaging 56 kph.

Such cruise speeds are consistent

with those achieved by a variety of species, from hummingbirds to geese.

Ledbury, Herefordshire, UK

Ideas running dry?

From Roy Smith
I was puzzled by your short article about an electronic shirt that knows when the wearer is thirsty



(29 November, p 23). We are told "as the person becomes thirsty the shirt will send alerts reminding them to drink".

Isn't that what the sensation of thirst does? Talk about pointless, redundant and wasteful technology. For their next trick, how about a hat that reminds you to breathe?

Burntwood, Staffordshire, UK

For the record

■ A touch of monkey business
affected our article on technology for animals: orang-utans become sexually active at 8 years, and it is human visitors – not other apes – that juveniles enjoy poking with sticks (29 November, p 44).

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CONCEPTS

Science is full of mind-blowing and counterintuitive concepts. To make any progress at all, scientists must get their heads around infinity, space, deep time, relativity and more.

Over the next 10 pages the people who perform these conceptual feats on a daily basis describe how they do it and provide some tips on how you too can think like a pro

- 1 HIGHER DIMENSIONS
- 2 SPACE-TIME
- 3 QUANTUM REALITY
- 4 COMPUTING
- 5 INFINITY
- 6 DEEP TIME
- 7 THE BIG BANG
- 8 PROBABILITY
- 9 MATHEMATICS
- 10 FIELDS
- 11 RELATIVITY
- 12 EVOLUTION
- 13 ALIEN CONTACT

HOW TO THINK ABOUT

1

HIGHER DIMENSIONS



There's hardly a problem that physicists haven't tried to solve by adding extra dimensions to our everyday three of space and one of time: whether with crunched up dimensions too small to see, or the idea that our 4D world exists on a "brane" floating in an inaccessible higher dimensional world.

How to envisage such things? Physicist Carlo Rovelli of the University of Marseilles, France, doesn't personally have much truck with more than three spatial dimensions – "I do not think they exist," he says – but he finds extra dimensions easy enough to picture. "It is just a space where you can go up-down, left-right, ahead-back, but also in one other dimension, something like leftB-rightB," he says. "It is a bit like having many arms, like an Indian god."

Others are more circumspect. "Visualising higher dimensions is certainly harder," says Don Marolf of the University of California, Santa Barbara (UCSB). One standard trick is to start at the bottom and work your way up, extrapolating your understanding of lower dimensions to higher ones. The principle is illustrated in Edwin Abbott's 1884 classic novella *Flatland*. When the 3D Sphere passes through 2D Flatland, the inhabitants of the 2D plane perceive the sphere as a sudden dot that grows into a big circle before diminishing back into a dot again.

Even if this process of slicing a higher-dimensional object into a series of projections becomes impossible to envisage in more dimensions than three, it will always work in this way: simply add extra dimensions to your equations, supplementing the standard x, y, z and t with extra coordinates, say w or s. "In the end there is always mathematics," says Joe Polchinski, also at UCSB.

Polchinski's speciality is string theory, still the most favoured route to unifying quantum theory and general relativity, the two irreconcilable underpinnings of modern physics. Depending on what variant you choose, it requires 10 or 11 dimensions. The mathematics works fine. As to whether these dimensions actually exist – well, that's anyone's guess. **Anil Ananthaswamy**



2

HOW TO THINK ABOUT SPACE-TIME

Space-time. Often described as the fabric of reality, this four-dimensional amalgamation of space and time was set at the heart of physics by Einstein (see “Relativity”, page 40). But what is it?

A popular way of envisaging space-time is as a stretchy rubber sheet that deforms when a mass is placed on it, with the varying curvature analogous to the warping of space-time by gravity.

It’s a picture that might lead us to believe space-time is itself something physical or tangible. But the physical manifestation of the dimensions we move through is, if anything, the fields they contain (see “Fields”, page 39). For most physicists, space-time itself is a lot more abstract – a purely mathematical backdrop for the unfolding drama of the cosmos. Martin Bojowald of Penn State University in Philadelphia sees it as a mathematical entity called a manifold. The equations of general relativity allow us to calculate the evolution of this manifold, and so of the universe itself, over time. “The rubber sheet is a picture for such a manifold, so in an abstract way I am indeed using the analogy,” he says.

Don Marolf of the University of California, Santa Barbara, goes even

further. “Visualising the ‘shape’ of space-time is very useful,” he says. “But most of us don’t visualise it as something particularly physical. To the extent that we draw pictures, they are just chalk lines on the blackboard.”

One thing that unifies all of these conceptions of space-time is that it is a “continuum”, something that varies smoothly with no abrupt knobs, bumps or tears. But if we want to combine general relativity with quantum mechanics to create a unified theory of quantum gravity, that notion must change. In quantum gravity, space-time is made up of tiny discrete quanta just like everything else – making it a fabric with a discernible warp and weft.

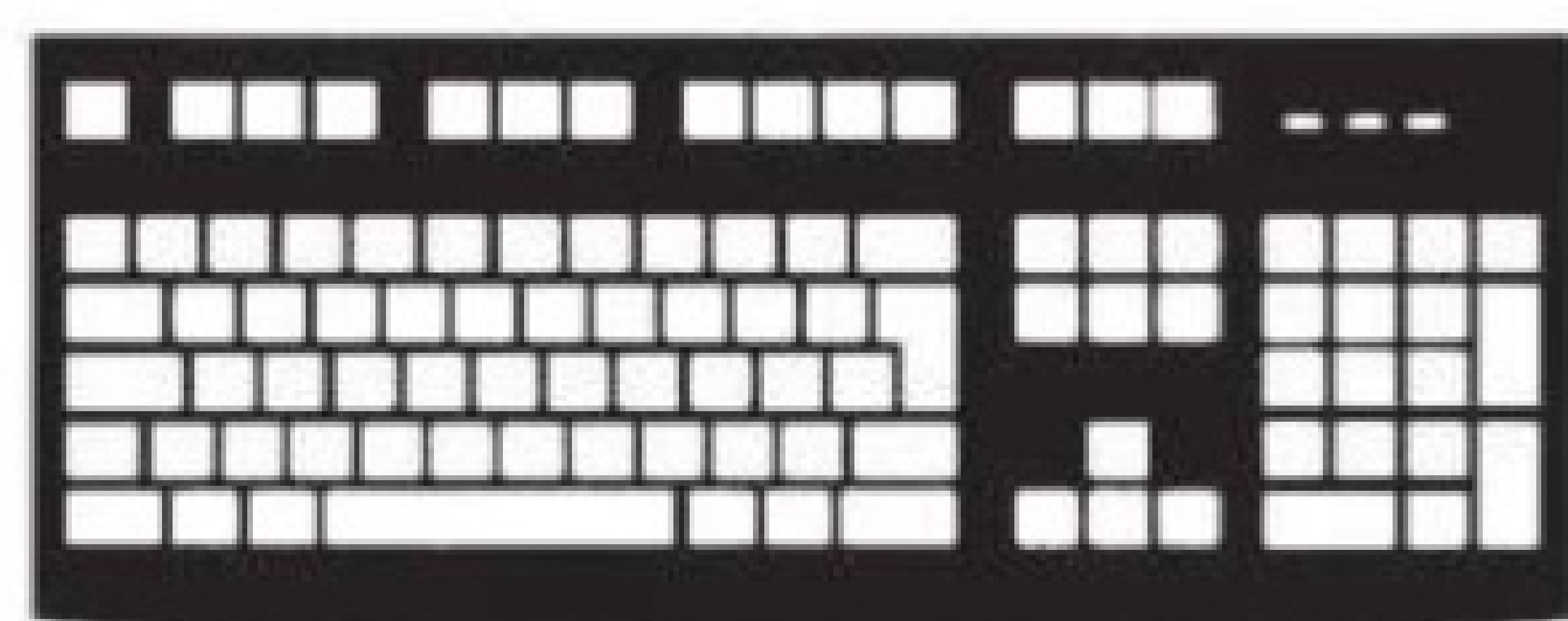
“Fabric as opposed to a rubber sheet means that we are focusing more on what possible microstructures space-time may have,” says Bojowald. Carlo Rovelli of the University of Marseilles, France, visualises this woven microstructure as being made of “tiny fuzzy blobs”, the starting point of his theoretical investigations of quantum gravity. It’s still just a device, though: something that helps him work with the intangible. “If I do not have an image in my head, I cannot even start thinking,” he says. **Anil Ananthaswamy**



MARIO WAGNER

4

HOW TO THINK ABOUT COMPUTING



We all know what computers are, right? They sit on our desks and in our pockets, and put the smarts into everything from cars to washing machines.

That’s not wrong – and yet it’s not entirely right.

At its most basic, a computer takes information as an input, transforming it according to some predetermined rules into a different output. The digital electronic computers that rule

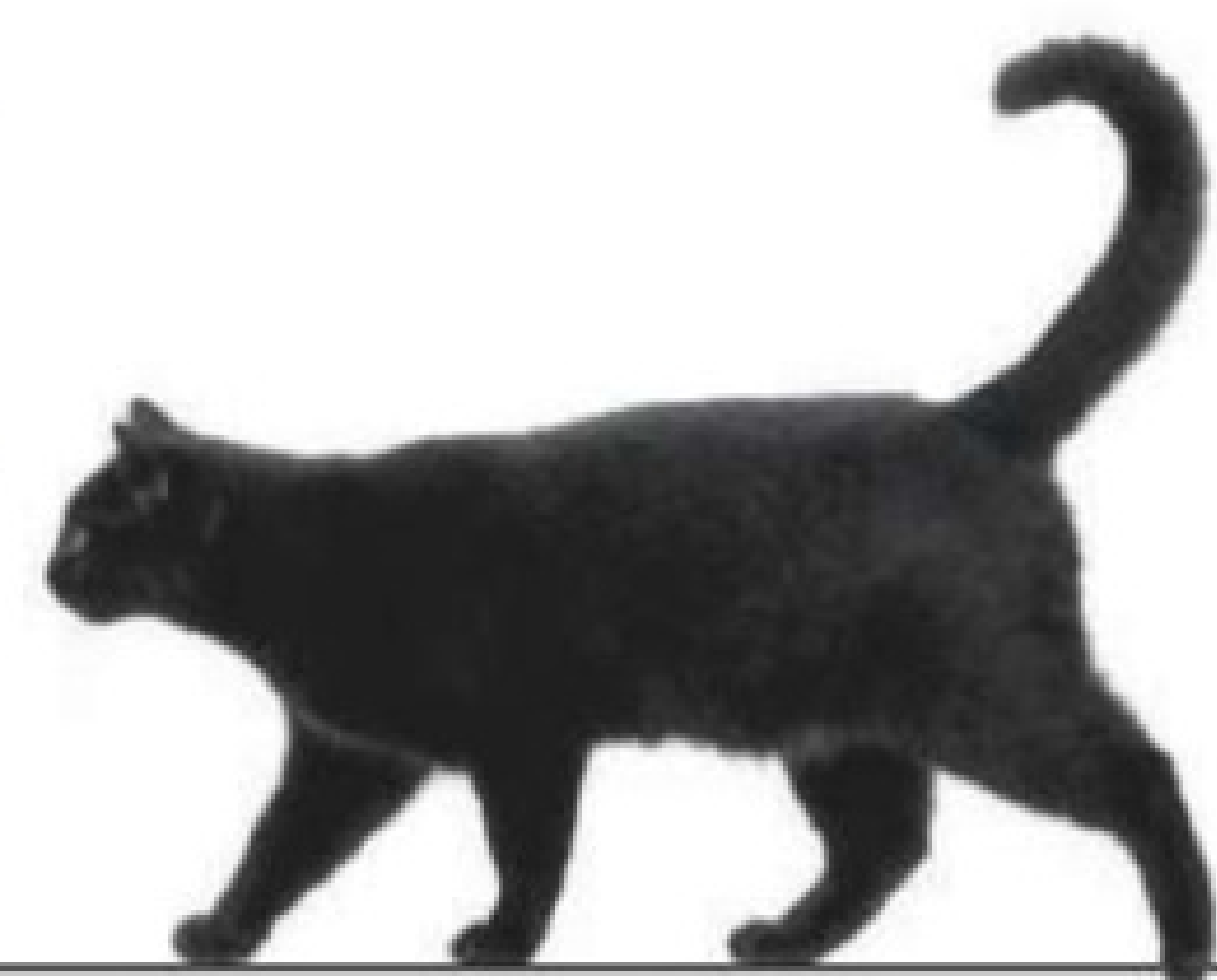
our world do this using little pulses of electric current. But there’s no reason it has to be that way. “An abacus allows us to compute by moving stones around,” says Peter Bentley at University College London. “If you can do that, I struggle to think of anything you cannot compute with.”

Sundials convert shadows to time, the liver regulates chemical outputs according to inputs, even rocks store mineral compositions for later breakdown and release: all of these things fit the broadest definition of a

3

HOW TO THINK ABOUT

QUANTUM REALITY



I believe in an external physical reality beyond my own experience,” says Johannes Kofler of the Max Planck Institute of Quantum Optics in Garching, Germany. “The world would be there without me, and was there before me, and will be there after me.”

Given what we know about quantum physics, that seems a bold statement. The assaults that this most fundamental theory of reality makes on our intuition are legion: particles that exist as probabilistic wave functions in “superpositions” of multiple states or places, or at least seem to as long you don’t look at them; “entangled” particles that influence each other over vast distances of space when you measure one of them.

For Aephraim Steinberg at the University of Toronto in Canada, dealing with such troubling concepts is a matter of retraining our brains. “As much as we talk about ‘counter-intuitiveness’ of quantum mechanics, we just mean that it’s counter to the intuitions we have before we learn

quantum mechanics,” he says. After all, we aren’t that great at second-guessing aspects of classical reality, either: how many of us would naturally say that feathers and bricks fall at the same rate under gravity?

With quantum physics, though, it doesn’t help that the quantities used to describe objects seem to exist only mathematically. Visualising a wave function as a real thing is fine for a single particle, but things rapidly get more tricky. “Once you’re talking about more than one particle, the wave function lives in some high-dimensional space I don’t know how to visualise,” says Steinberg. He ends up having to break a complex quantum system down into parts. “But they’re all merely ways of chipping away at the abstract mathematical object I know provides the complete description.”

More fundamentally, though, if you accept quantum physics at face value then at least one of two dearly held principles from the classical world must give. One is realism, the idea that every object

has properties that exist without you measuring them. The other is locality, the principle that nothing in the universe can influence anything else “instantaneously” – faster than the speed of light.

For most quantum physicists, it’s realism that has to give, given all the evidence that the cosmic speed limit is never broken. The Copenhagen interpretation is the most widespread of the approaches that result, says Kofler. This demands that at least some properties of microscopic objects don’t exist prior to and independent of measurement. Alternatively, physicists resort to the many worlds interpretation, in which all possible results of a measurement happen, each spawning a different universe – whatever that means.

It’s fair to say that no one really gets all this. That means practitioners of quantum physics need to guard against relying too heavily on new intuitions and imagery, says Steinberg. “That’s exactly the point at which one develops a dangerous self-confidence.” **Anil Ananthaswamy**

computer. “The notion of ‘computation’ currently appears to float dangerously free of its foundations,” says Mark Bishop of Goldsmiths, University of London.

One way out is to suggest a hierarchy of computing machines. At the bottom are “finite state machines”: things like traffic lights and elevators that do little more than cycle through a limited series of input and output states.

Digital computers fall into the category of Turing machines. As

conceived by Alan Turing in the 1930s, these read symbols from an infinitely long input tape and substitute them according to a set of rules, thereby simulating the behaviour of any conceivable algorithm. Basic though it seems, this still provides perhaps the best understanding of the limits of computation, says Bentley.

According to Turing’s model, though, there are well-defined problems that no computer can answer, such as the self-referential Halting problem, which asks “Will this

program stop?”. No computer can say yay or nay without actually running the program (and possibly stopping). Other problems, though theoretically computable, take an almost endless time to solve. “Computer science was born very conscious of its limitations,” says Christos Papadimitriou at the University of California, Berkeley.

Models of computing more powerful than Turing machines do exist; Turing himself speculated about them (*New Scientist*, 19 July, p 34). Some people think biological

processes might be able to implement such “super-Turing” computation, accounting, perhaps, for some of our own excessive smarts. Others think that super-Turing models can only work by breaking the laws of physics as we know them. If so, that suggests an intriguing and deep-seated connection between notions of computability and the workings of the universe. If we can’t quite get our head around computers, perhaps it is because we are sitting in the biggest of them all. Douglas Heaven

5

HOW TO THINK ABOUT INFINITY

Ian Stewart has an easy, if not particularly helpful, way of envisaging infinity. “I generally think of it as: (a) very big, but (b) bigger than that,” says the mathematician from the University of Warwick in the UK. “When something is infinite, there is always some spare room around to put things in.”

Infinity is one of those things with a preprogrammed boggle factor. Mathematically, it started off as a way of expressing the fact that some things, like counting, have no obvious end. Count to 146 and there’s 147; count to a trillion and say hello to a trillion and one. There are two ways of dealing with this, says Stewart. “You can sum it up boldly as ‘there are infinitely many numbers’. But if you want to be more cautious, you just say ‘there is no largest number’.”

Only in the late 19th century did mathematicians plump for the first option, and begin to handle infinity as an object with properties all its own. The key

was set theory, a new way of thinking of numbers as bundles of things. The set of all whole numbers, for example, is a well-defined and unique object, and it has a size: infinity.

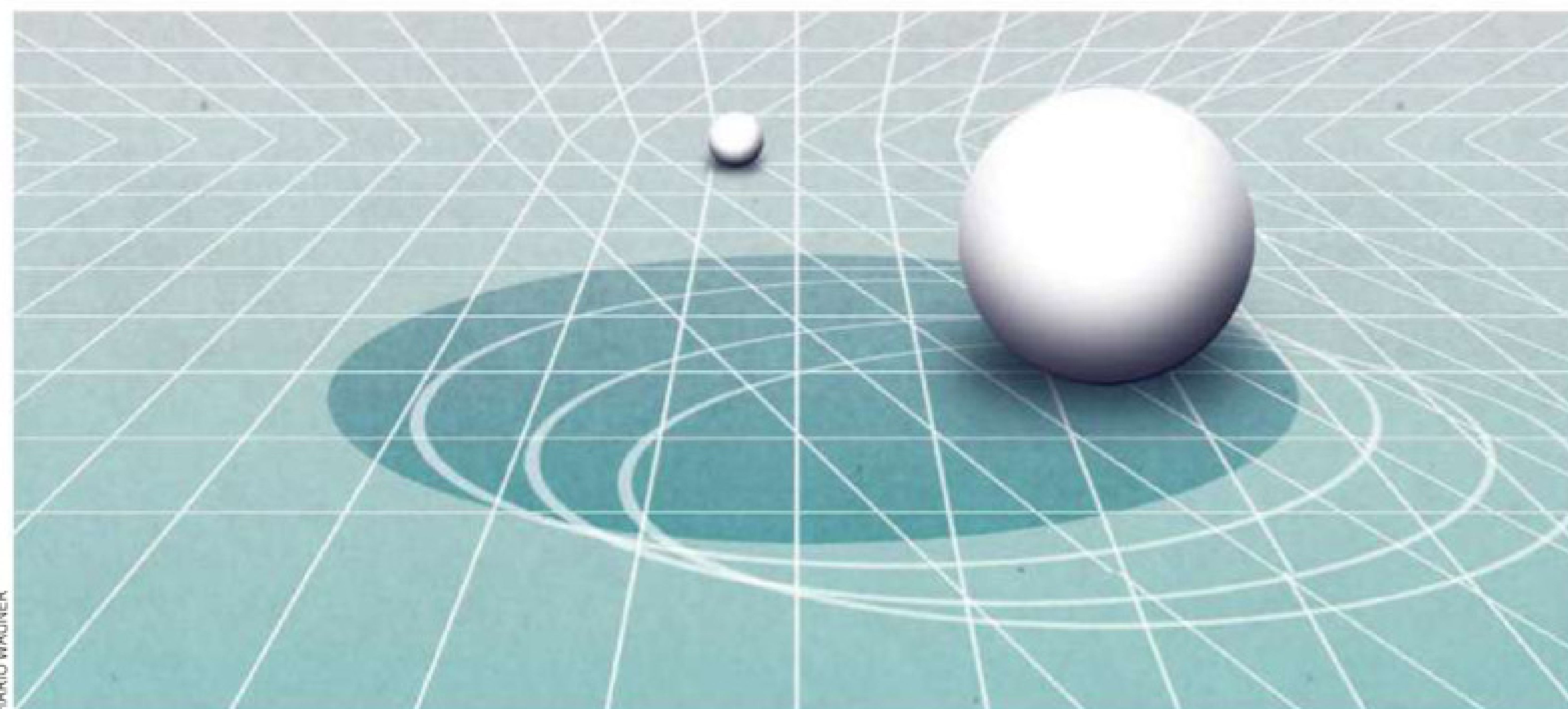
The sting in the tail, as the German mathematician Georg Cantor showed, is that by this definition there is more than one infinity. The set of the whole numbers defines one low-lying sort, known as countable infinity. But add in all the numbers in between, with as many decimal places as you please, and you get a smoother, more continuous infinity – one defined by a set that is infinitely bigger.

That is just the beginning. Hugh Woodin is a set theorist at Harvard University who has a whole level of infinity named after him, a particularly vertiginous level populated with numbers known as Woodin cardinals. “They are so large you can’t deduce their existence,” he says.

Such infinities help solve otherwise unsolvable problems in less rarefied mathematical

landscapes below. They are the ultimate abstraction: although you can manipulate them logically, you can’t write formulae incorporating them or devise computer programs to test predictions about them. Woodin’s notepads consist mainly of cryptic marks he uses to focus his attention, to the occasional consternation of fellow plane passengers. “If they don’t try to change seats they ask me if I’m an artist,” he says.

How closely our common-sense conception of endlessness matches the mathematical infinities isn’t clear. But if we can’t quite grasp boundarylessness, it probably doesn’t matter, says Woodin – however you slice it, infinity seems far removed from anything we see in the real world. Perhaps those enigmatic markings aren’t so different from those of his fellow passengers after all. “It might be we’re just playing a game,” says Woodin. “Perhaps we are just doing some glorified sudoku puzzle.” **Richard Webb**



6

HOW TO THINK ABOUT DEEP TIME

In June 1788, Scottish geologist James Hutton took his colleagues John Playfair and James Hall to Siccar Point on the Berwickshire coast. To unenlightened eyes, the rocky promontory would have appeared eternal and unchanging. But Hutton and his fellow travellers knew better. As Playfair later wrote: "The mind seemed to grow giddy by looking so far into the abyss of time."

Visit Siccar Point today and it still appears almost exactly as it did in 1788. Hutton realised that this continuity was an illusion, and that the sequence of events he could read in the rocks spoke of unimaginably slow changes occurring over mind-expanding stretches of time. The "angular unconformity" of rocks layers of varying types and orientation could only have formed over tens of millions of years. It was a crucial piece of evidence in his theory of Earth's gradual evolution and the revolutionary concept of deep time.

Little more than a century earlier the Primate of All Ireland, Archbishop James Ussher, had used the Bible and other sources to pinpoint the date of creation to Sunday 23 October 4004 BC. Isaac Newton disagreed: he thought the year was 3988 BC. Then, as now, deep time went deeply against the grain of common sense.

"Measuring things against a human lifespan is a normal and natural way to think," says John McNeill, an environmental historian at Georgetown University in Washington DC.

Through the heroic efforts of Hutton and many after him, we now know that Earth is around 4.54 billion years old and the

universe about 13.8 billion. Our world is almost inconceivably old.

Deep time was central to the development of the historical sciences – geology, evolutionary biology and cosmology – and remains so. "Their ruling ideas absolutely depend on dealing with deep time," says McNeill. Without it, we can't appreciate that some processes, whether the weathering of rocks, the evolution of species or the formation of galaxies, generally occur on timescales so slow as to be inappreciable within a human lifespan. "We might be misled into supposing all is stationary, as most people in most cultures have," says McNeill.

As Playfair found, trying to conceive deep time can induce vertigo, and our odd glimpses of it – ancient fossils dug from geological strata, pictures of star fields from the deep cosmos – can be hard to deal with. But for McNeill it is also liberating. "What it means to me is that we are all part of an unimaginably long chain of being, both human and non-human, and our own travails don't amount to a hill of beans."

Graham Lawton



7

HOW TO THINK ABOUT THE BIG BANG

Space is big, wrote Douglas Adams in *The Hitchhiker's Guide to the Galaxy*. "Really big. You just won't believe how vastly hugely mindbogglingly big it is." Too right: the edge of the observable universe is some 46 billion light years away. Within that volume there are anything between 100 and 200 billion galaxies, each containing hundreds of billions of stars.

If that weren't mind-blowing enough, according to the big bang theory – our best stab at explaining how it all came to be – everything exploded into being from nowhere, about 13.8 billion years ago. An infinitesimal pinprick of unimaginable heat and density has slowly stretched and cooled into the cosmos we know today.

How can we get our heads around that? For cosmologist Martin Rees of the University of Cambridge there are two strategies: bury yourself in equations, or draw pictures. "I'd put myself in the picture camp," he says.

He envisages the expanding universe by imagining himself at one node of a three-dimensional lattice stretching as far as the mind's eye can see, with the nodes linked by rods, all of which are expanding. That way you can visualise the universe moving away from you in all directions – while recognising that you would see the same thing from any other node. "You understand there is no central position," he says.

There's also no discernible edge: periods of accelerated expansion during the universe's earliest instants and in more recent aeons mean that the horizon of the observable universe is by no means the end of all things. Beyond it are galaxies we will never see because the intervening space is expanding too fast, so their light can never reach us. "I think it is fair to say they are retreating from us faster than the speed of light," says Rees.

Even more challenging is to envisage what came before the big bang. Our current conceptions of physics suggest the question makes no sense: as we rewind time to the very first instants, the intense concentration of energy jumbles up even space and time in a confusion of... stuff. "There is no direction of time, so there's no before and after," says Rees. "The analogy that's always made is it's like asking what's north of the North Pole."

Not that this stops some physicists trying. The theory of eternal inflation proposes that when the universe began in the big bang, it might just have been one of a multitude budding off from a larger entity – and that other universes might constantly be budding off our own. "Is there a beginning in that theory?" asks Rees. "If you have universes sprouting and they are governed by different physical laws, what then? That's where my intuition breaks down completely." Richard Webb

8

HOW TO THINK ABOUT PROBABILITY



THE MONTY HALL PROBLEM

Suppose you're on a game show, and you're given the choice of three doors

"Pick a door"



Behind one door is a car; behind the others, goats

You pick a door, say **No. 1**, and the host, who knows what's behind the doors, opens another door to reveal a goat



The host then says to you,

"Do you want to switch to number 2?"

Counter-intuitively, you should **switch**. Here's why

YOU PICK						
1	2	3	HOST OPENS		You STICK	You SWITCH
Car	Goat	Goat	or	Goat	✓	✗
Goat	Car	Goat			✗	✓
Goat	Goat	Car			✗	✓

The fact that the host knows what is behind the doors affects your chances so the win ratios are

1/3

2/3

The same applies if you pick 2 or 3

Probability is one of those things we all get wrong... deeply wrong. The good news is we're not the only ones, says John Haigh, a mathematician at the University of Sussex in Brighton, UK, and author of *Probability: A very short introduction*. "Many pure mathematicians claim that probability has many unreasonable answers."

Take the classic problem of a class of 25 schoolchildren. How likely is it that two of them share the same birthday? The common-sense answer is that it is not implausible, but quite unlikely. Wrong: it's actually just under 57 per cent.

Or the celebrated Monty Hall problem, named after the former host of US television game show *Let's Make a Deal*. You're playing a game in which there are three doors, one hiding a car, two of them goats (see illustration, left). You choose one door; the host of the game then opens another, revealing a goat. Assuming you'd rather win a car than a goat, should you stick with your choice or swap?

The naive answer is it doesn't matter: you now have a 50-50 chance of striking lucky with your original door. Wrong again.

But if probability makes even experts grumble, how do we get it right? Simple, says mathematician Ian Stewart of the University of Warwick in the UK: do things the hard way. "The important thing with probability is not to intuit it," he says. Think carefully about how the problem is posed and do your sums diligently, and you'll arrive at the right answer - eventually.

With the birthday problem, the starting point is to realise that you're not interested in individual schoolchildren, but pairs. In a class

of 25, there are 300 pairs to consider and in most years 365 days on which each might share a birthday. Factor all that in, and you end up crunching some truly astronomical numbers to arrive at the answer. "Any coincidence like that is remarkable in itself, but when you ask how many times it would happen, that number is so vast it's not remarkable at all," says Haigh.

With the Monty Hall problem, meanwhile, the chance you chose the right door in the first place is 1/3 - and that doesn't change whatever happens afterwards. Since the host has revealed a goat, there is now a 2/3 probability that the car is behind the other door - and you are better off swapping.

There are a few caveats: if the host is so devious as only to open a door if you chose the right one in the first place, you'd be mad to swap. Ditto if you want a goat rather than the car. That illustrates another important rule in thinking about probability, says Haigh. "It is very important to know your assumptions. Very subtle changes can change the outcome."

All this is very well when the boundaries of the problem are clear and the possible outcomes quantifiable. Toss a fair coin and you know you have a 50 per cent chance of heads - because you can repeat the exercise over and over again if necessary.

But what about a 50 per cent chance of rain today, or of a horse with even odds winning a race? No amount of expert advice can help us assess the true worth of such "subjective" probabilities, which are fluid and often based on inscrutable expertise or complex modelling of an unpredictable world. Sometimes you do just have to go with your gut instinct - and be prepared to be wrong. Richard Webb

HOW TO THINK ABOUT

MATHEMATICS

Mathematics is like a language – but one that, thanks to its inbuilt logic, writes itself. That’s how mathematician Ian Stewart sees it, anyway. “You can start writing things down without knowing exactly what they are, and the language makes suggestions to you.” Master enough of the basics, and you rapidly enter what sports players call “the zone”. “Suddenly it gets much easier,” Stewart says.

“You’re propelled along.”

But what if you don’t have such a maths drive? It’s wrong to think it’s all down to talent, says mathematician and writer Alex Bellos: even the best exponents can take decades to master their craft. “One of the reasons people don’t understand maths is they don’t have enough time,” he says. “It’s not supposed to be easy.”

Sketching a picture of the problem helps. Take negative numbers. Five sheep are easy enough to envisage, but what

about minus five? “We can’t see the minus five sheep, so you can’t get your head around it,” says Bellos. It was only when someone had the bright idea of arranging all the existing numbers 0, 1, 2, 3... on a line that it became obvious where the negative numbers fitted in. Similarly, complex numbers – 2D numbers that underpin the mathematics of quantum theory, among other things – only really took off with the advent of a “complex plane” in which to depict them.

Analogies also help. If thinking about ellipses oppresses you, think about a circle that’s been squashed and work from there, says Stewart. Overall, contrary to the impression of mathematics as a discipline of iron logic, the best way to attack a problem of any sort is often to get a brief overview of it, skip over anything you can’t work out and then go back and fill in the details. “A lot of mathematicians say it’s important to be able to think vaguely,” says Stewart. **Catherine de Lange**

10

HOW TO THINK ABOUT

FIELDS



Frank Close has a question. “If you step off the top of a cliff, how does the Earth down there ‘know’ you are up there for it to attract you?” It’s a question that has taxed many illustrious minds before him. Newton’s law of gravitation first allowed such apparently instantaneous “action at a distance”, but he himself was not a fan, describing it in a letter as “so great an Absurdity that I believe no Man who has in philosophical Matters a competent Faculty of thinking can ever fall into it”.

Today we ascribe such absurdities to fields. “The idea of some physical mediation – a field of influence – is more satisfying,” says Close, a physicist at the University of Oxford. Earth’s gravitational field, for example, extends out into space in all directions, tugging at smaller objects like the moon and us on top of a cliff; the Earth itself is under the spell of the sun’s gravitational field.

But hang on: what exactly *is* a field? On one level, it is just a map. “Ultimately, a field is something that depends on position,” says Frank

Wilczek, a theoretical physicist at the Massachusetts Institute of Technology. A gravitational field tells us the strength of gravity at different points in space. Temperatures or isobars on a weather chart are a field. A field is a mathematical abstraction – numbers spread over space.

But there is more to it than that. Witness what physicist Michael Faraday saw in the 19th century, and many a schoolkid has since: iron filings neatly ordering themselves along the lines of a magnetic field, reaching out into space from the magnet itself and influencing nearby objects (though at the speed of light, not instantaneously). “It made a huge impression on Faraday, that this strange thing had a physical reality,” says Wilczek.

Arguably the modern world is built on the principle of electromagnetic induction that Faraday developed out of his new understanding of fields: magnetic fields and electric fields power the motors of our civilisation. A mere abstraction?

The modern era has shed some further light on fields, but also added

confusion. Quantum fields – ultimately, the electromagnetic field is one – have tangible products in the form of particles, which pop up as disturbances within them. For the electromagnetic field, this entity is the photon. The Higgs field, long postulated to pervade empty space and to give elementary particles their mass, was discovered in 2012 by squeezing out its particles in high-energy collisions.

But quantum fields are complicated beasts, formed of “superpositions” of many classical fields. That’s far away from anything we can envisage as a map, or delineate as neat lines. “At that point I have to rely on equations,” says Wilczek, who won a Nobel prize for his work on the quantum fields of the strong nuclear force.

One thing’s for sure: fields are everywhere. Quantum theory teaches us that even seemingly empty space is a roiling broth of fields and their associated particles. “The idea that nothing’s there is extremely naive,” says Wilczek. Aside from anything else, fields are the proof that nature does indeed abhor a vacuum.

Richard Webb

HOW TO THINK ABOUT RELATIVITY

11

Space and time used to be so simple. You trundled around reasonably freely in the three dimensions of the one, and experienced occasional heartache at the remorseless forward march of the other. C'est la vie.

Or is it? Einstein revolutionised our perceptions a century ago when, in his theories of relativity, he first forbade anything in the cosmos from travelling faster than the speed of light, and then bundled both space and time into one unified space-time that can be warped by gravity (see Space-time, page 34). The contortions introduced by Einstein's special and general theories make intervals in both space and time dependent on where we measure them from. Two observers with flashlights in fast-moving trains might both measure the other to have flashed their flashlight first – and both be right from their own point of view.

The recent blockbuster *Interstellar* is based on premises that Einstein made technically plausible, if not (yet) technologically feasible: that by travelling close to the speed of light, or moving in an intense gravitational field such as that of a black hole, we age more slowly than those we leave behind on Earth. We don't need to travel that far to see less dramatic effects of relativity in action. Astronauts on the International Space Station age a little less because of the velocity at which they travel, and a little more for enjoying less of the gravity of mothership Earth. The effects don't quite cancel out. Velocity wins, leaving each ISS astronaut who completes a six-month tour of duty 0.007 seconds younger than someone who stayed on Earth.

For most everyday purposes, such effects matter not a jot. But for physicists like Sean Carroll of the California Institute of Technology in Pasadena, who peer deep into the cosmos, relativity is a crucial consideration. He often resorts to drawing a diagram. "As far as special relativity goes, it's very natural to think in terms of pictures," he says. Relativity can seem full of paradoxes if we don't first think carefully about how our own motion affects our perception of how time is passing for others – but also how others might see our time passing differently, too.

Carroll has a few rules of thumb to guide his own perceptions. "Basically, time is kind of like space, but not exactly," he says. The main difference is that

whereas in space a straight line is the shortest distance between two points, in time it is the longest. The way to minimise the time you experience between two events that occur at the same point in space is to move as far and as fast as you can in the interim. "If you zoom off near the speed of light, then zoom back, you will experience less time than someone who simply sits still," says Carroll. So time passes slowly when you're having fun. **Richard Webb**

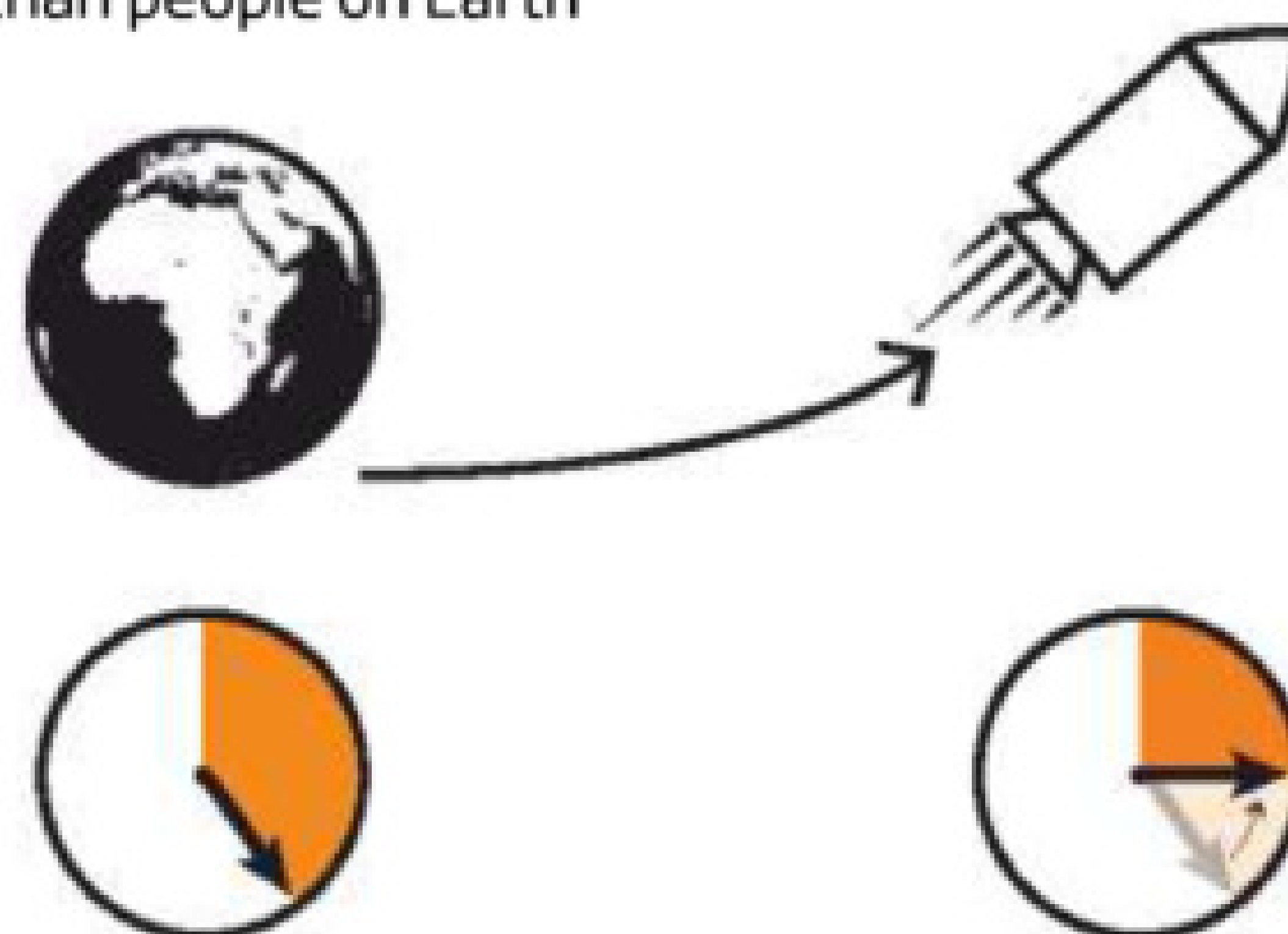
INTERSTELLAR SCIENCE

Einstein's theories of relativity – special and general – encompass two effects that influence our perception of space and time

SPECIAL RELATIVITY

Moving clocks run slower

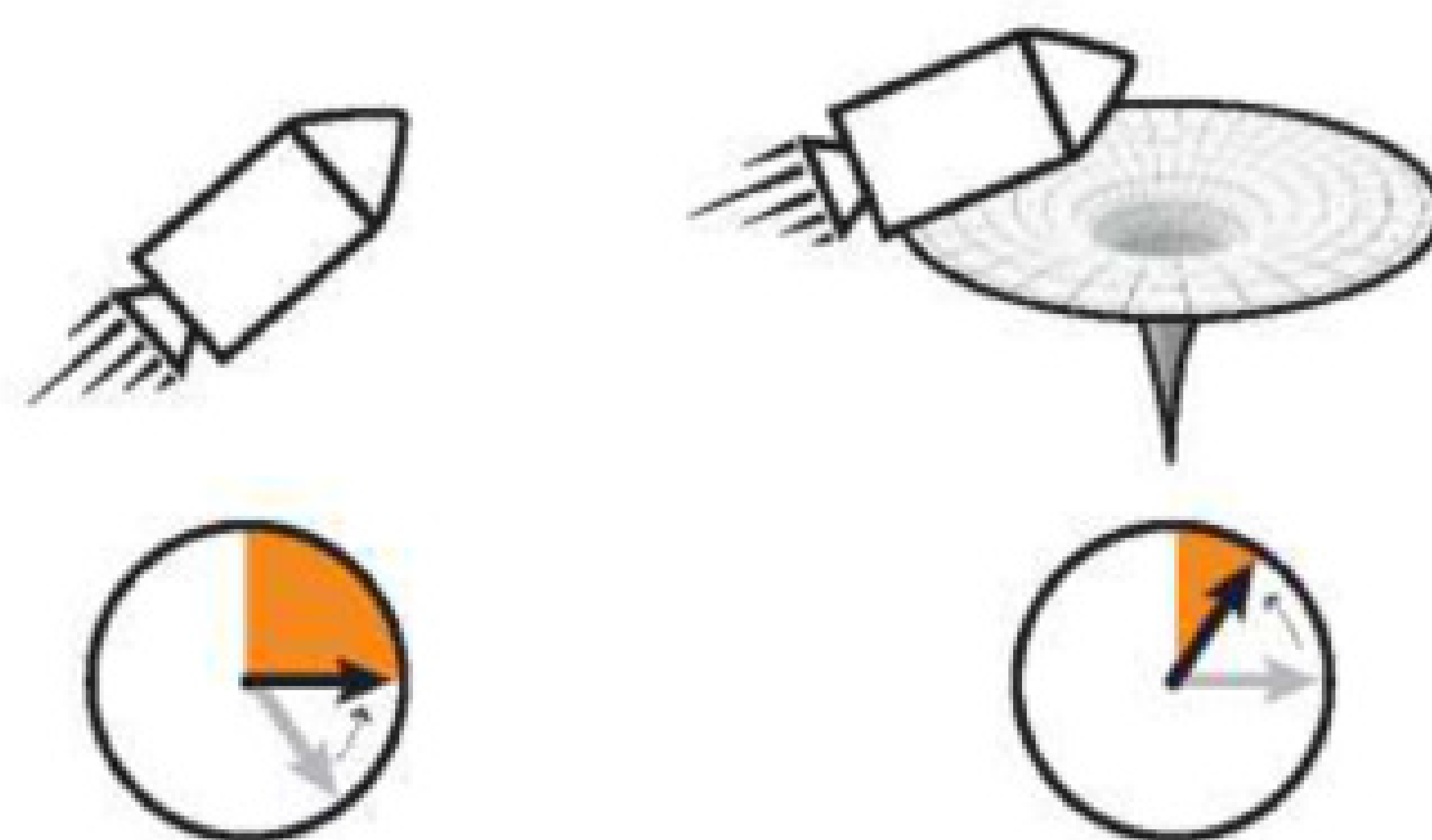
To an outside observer, the crew of a spaceship travelling close to the speed of light will age less than people on Earth



GENERAL RELATIVITY

Clocks run slower in high gravity

A spaceship entering a high gravitational field like that of a black hole will experience even less time



12

In a cave, a bear gives birth to two cubs one long dark night. In the morning, the weak winter light reveals something strange: the cubs' fur is white, in stark contrast to the dark fur of their mother. They are freaks... or are they?

What is evolution? Easy, you might think: it's the way living organisms change over time, driven by natural selection. Well, that's not wrong, but it's not really how evolutionary biologists think of it.

Picture those bear cubs. Here we see a dramatic physical change, but it isn't evolution. Among black and brown bears, white bear cubs are not that uncommon. But white bears don't have more cubs than other bears, so the gene variants for white fur remain rare.

Among one group of brown bears living in the Arctic, though, white fur was an advantage, helping them sneak up on prey. There white bears thrived and had more offspring – their "fitness" increased – so the proportion of white bears rose until the entire population was white. This is definitely evolution. It happened as polar bears evolved from brown bears a few million years ago.

So although we tend to think about evolution in terms of the end results – physical changes in existing species or the emergence of new ones – the key concept is the spread of genetic variants within a population.

This results of this process can appear purposeful. Indeed, it is convenient to talk as if they are: "polar bears evolved white fur for camouflage". But it all comes down to cold numbers: a random mutation that boosts fitness spreading in a population.

HOW TO THINK ABOUT EVOLUTION



STEVEN KAZLOWSKI/SCIENCE FACTION/CORBIS

When does a dramatic physical difference become evolution?

What's more surprising is that even mutations that don't increase fitness can spread through a population as a result of random genetic drift. And most mutations have little, if any, effect on fitness. They may not affect an animal's body or behaviour at all, or do so in an insignificant way such as slightly altering the shape of the face. In fact, the vast majority of genetic changes in populations – and perhaps many of the physical ones, too – may be due to drift rather than natural selection. "Do not assume that something is an adaptation until you have evidence," says biologist Larry Moran at the University of Toronto, Canada.

So it is wrong to think of evolution only in terms of natural selection; change due to genetic drift counts too. Moran's minimal definition does not specify any particular cause: "Evolution is a process that results in heritable changes in a population spread over many generations."

It does not even have to involve many generations, says Michael Kinnison of the University of Maine in Orono, who studies how

living species are evolving. Evolution occurs almost continuously, he says. It usually takes time for populations to change significantly, but sometimes it happens very fast, for instance when only individuals of a particular genetic type survive some catastrophe, or when only tumour cells with a particular mutation are not killed by a cancer drug.

In these cases, there is no need to wait for the survivors to reproduce to determine that the population has changed. "I would say evolution occurs whenever some process changes the distribution of heritable traits in a population, regardless of the time scale," Kinnison says. "While evolutionary biologists like to treat evolution as a generation-to-generation process, that is often more a matter of convenience than reality."

Suppose those white bear cubs somehow reached an island and founded a new bear population. The interbreeding of white bears always produces white offspring, and thus being white would be normal there. So we can boil down the concept of evolution to just six words: Evolution is what makes freaks normal. **Michael Le Page**

13

HOW TO THINK ABOUT ALIEN CONTACT

We must realise that there are other worlds in other parts of the universe, with races of different men and different animals." That was the Roman poet Lucretius, writing in the 1st century BC.

Only in the past few decades have we grasped the truth of the first part of that statement, thanks to planet-hunters such as NASA's Kepler space telescope. Almost 5000 suspected planets have already been spotted outside our solar system, and stars nursing planets seem to be the rule, not the exception. With hundreds of billions of stars in our galaxy alone, that's an awful lot of worlds.

Surely, then, it's only a matter of time before we confirm the second part by finding signs of life.

Perhaps. Life on Earth has required billions of years to evolve organisms capable of asking such questions, and that process has been anything but inevitable. Other life, if it exists, may be nothing like life as we know it.

This is the central dilemma of searches for ET, says Jeffrey Scargle of the NASA Ames Research Centre in Moffett Field, California. "You can't assume nothing because then you don't even know how to start looking, but if you assume too much then you're biased and you're not open to finding a lot of things that might be there."

So alien life might be

carbon-based, and ultimately get its energy from starlight through a process like photosynthesis. Or it might work entirely differently, in which case searches for the metabolic products of carbon-based life in far-off atmospheres – oxygen, methane and the like – will never be a smoking gun.

Perhaps more conscious signals from similarly questioning advanced civilisations are a better bet. "It's natural to assume that any intelligent civilisation would have that concept of needing to wave a flag," says Scargle. He is studying Kepler data for signs of "star-tickling": variations in a star's brightness induced by aliens using it in some way as a beacon. But as far as decoding any message goes, he's sceptical: even our idea of what counts as a regular pattern might not be shared by others.

Scargle's colleague Lucianne Walkowicz points out that even looking for something like radio transmissions might be assuming too much. "Earth is getting quieter as it gets more advanced, not louder," she says. And what if we were to pick up an incontrovertible signal of alien civilisation from, say, 10,000 light years away across the Milky Way? That would tell us of something existing 10,000 years ago – a long time by the measure of human civilisation to date. Perhaps even a lively cosmos is a lonely one.

Douglas Heaven ■



Soils of war

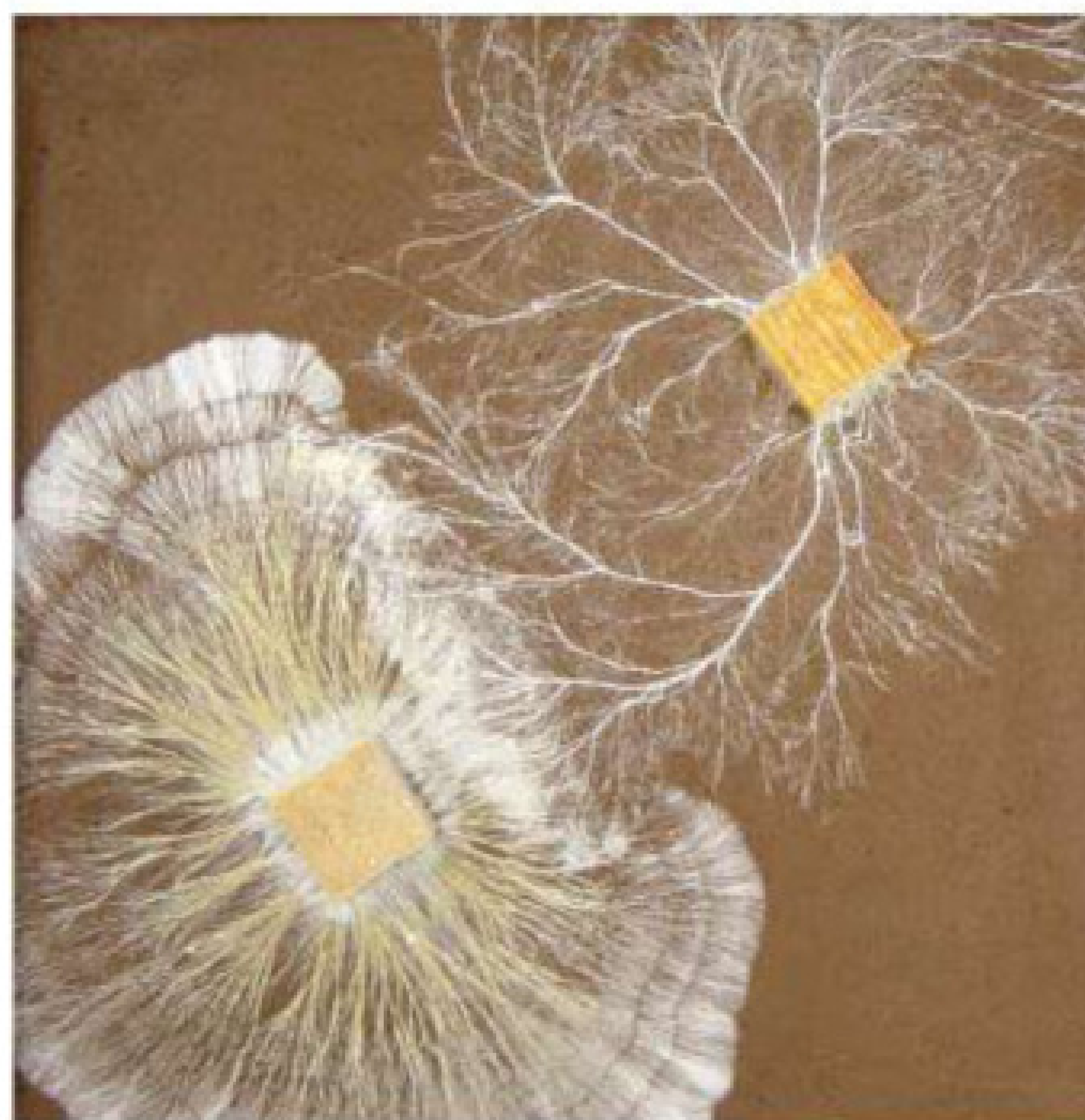
Brutal battles for fungal supremacy rage in the most tranquil of settings, says mycologist **Lynne Boddy**

TO CRUNCH your way across a meadow or through a wood on a crisp winter's day is to traverse a battlefield. That rural tranquillity is a mere veneer. Beneath the soil, in those piles of falling leaves or that moss-covered tree stump, war is being waged.

You might see the standards of some of the troops standing proudly above the surface: perhaps a field mushroom, or a bracket fungus. The passivity is deceptive. Out of sight, scenes of peculiar barbarism and brutality are being played out. One-on-one combat, stealth assassination, chemical warfare, even mind control: when mushrooms get martial, the Geneva conventions most definitely do not apply. You may find some of the scenes I am about to describe disturbing.

Before we delve into gory details, however, a big word in defence of fungi. This diverse and distinct kingdom of organisms – neither plant, animal nor bacterium – is largely responsible for breaking down and recycling bulky, dead plant tissues. Fungal activity releases the nutrients locked inside material rich in lignin and cellulose, from leaves and twigs to mighty trunks, so that further generations of plants can grow.

Fungi thus ensure that land-based ecosystems thrive. They probably also created them in the first place, helping to make the first soils and assisting photosynthetic organisms in colonising the land. One particular group, the mycorrhizal fungi, feed nutrients and water directly into plant roots, and are paid for this service with sugars from the plant. In this intimate relationship, which evolved just as life was getting a toehold on land about 450 million years ago, fungi colonise the fine roots of plants and extend into soil as long thin tubes called hyphae, the better to gobble up nutrients for both



Fungal battles can be restaged in the lab

Even if fungal ends are justified, we can still blanch at some of the means. Fungi are territorial beasts, and recognise their own. If the mycelium of any individual fungus – the mass of interconnected hyphae that forms its generally hidden body – splits into smaller networks, these happily grow independently. If they later encounter one another again, they will fuse back together to form a bigger mycelium and so pool resources.

It is another story when genetically different individuals of the same species meet: on touching, they will recoil behind the fungal equivalent of a picket fence. Actually, make that barbed wire: the dense, contorted, much branched walls of hyphae that fungi build to mark out their territory are not designed to invite friendly interaction. These impenetrable barriers are the lines, black or autumnal brown and orange,

that mark out spalted wood used to make decorative bowls and jugs.

But woe betide a mycelium encountering a different species of fungus – and as there are thousands of species in a typical woodland landscape, it happens often. This is when the battle lines are truly drawn.

For some fungi, war means bare-hand killing. Soil-dwelling fungi of the genus *Trichoderma*, for instance, coil around a victim's hyphae and use mechanical force and enzymes to penetrate it, sucking out food.

But mostly the means are more insidious (see "Natural born killers", page 44). We are familiar with some of the volatile chemicals that fungi produce, such as the odour of cooking mushrooms or the smell of rot. When fungal species encounter each other, chemical warfare often ensues. Some, such as the versatile assassin the sulphur tuft, produce agents such as sesquiterpenes that are as damaging to fungi as nerve gas is to humans, and quinolinium compounds like those used in commercial fungicides. The ubiquitous turkey tail fungus, on the other hand, is a poisoner. It secretes enzymes into the food sources on which the opponent fungus feeds, killing and dissolving the other combatant from inside, so its territory and food can be taken as spoils of war – assuming it avoids its own predators.

What unites fungal fighters is that they are bullies. Given a choice of several opponents, an aggressor will attack the weakest first, going for others only when it has consolidated its territory. Things don't always go to plan. Thanks to an evolutionary arms race that has been escalating for millions of years, the aggressor can often get as good as it gives. The chemical fallout from two evenly matched species can create a no

man's land no party can occupy.

While there is a natural hierarchy of combative ability in most fungal ecosystems, with some species good in attack and others good in defence, the conditions of the battlefield – whether it is warm or dry, or the availability and quality of food – can also be decisive. The sulphur tuft wins more battles in warmer weather, for example, while *Daldinia concentrica* or King Alfred's cake – named for its black fruit bodies that resemble charred bakery produce – is formidable when it is dry. Climate change might be expected to alter the outcomes of these hidden battles. Bystanders can influence the outcome too, by emitting some of their chemical arsenal or through skirmishes against a main contender.

If you look carefully, evidence of these epic battles abounds in the woods. The exploratory mycelium scouting for food and enemies is visible if you gently clear away the layer of leaves blanketing the woodland floor. Turning over a decaying log can reveal cords of hyphal aggregations, rather like the hawsers from a ship to the dockyard, creating a vast network on the forest floor. They are supply lines spreading crucial water and food around the system and to the front line: after all, an army marches on its stomach. The front lines themselves are harder to discern in the forest, but in lab cultures they are sometimes

“The fungus pushes hyphae into the nematode's body and liquidises its contents”

accompanied by blood red pigments, perhaps defensive chemicals, that make them look even more like human killing fields.

Fungi aren't just aggressive to their own kind. Nematodes – minute, worm-like soil-dwelling creatures – are favoured prey forming a nutrient-rich supplement to the diet. Fungi have evolved nematode traps of varying complexity, including adhesive protrusions that emerge on the hyphal surfaces like lethal lollipops, and adhesive nets and nooses to strangle the unwary.

Equally macabre demises are brought about by fungi producing spores that stick to the outsides of nematodes, or using hooks and protrusions that lodge within the worms' mouths. Irrespective of how the nematode has been incapacitated, the next step is the same: the fungus pushes its hyphae into the worm's body and liquidises its body contents.

Insects and other arthropods aren't safe, either. Their multilayered exoskeletons, made of waxes, lipoproteins and often anti-fungal compounds, protect their vulnerable interiors rather as an army tank protects its human cargo. But some fungi penetrate these defences and even evade haemocytes, specialised warrior cells sent out by the insect's immune system to seek and destroy invaders. Once inside, one group of fungi, the Entomophthorales – their name means “insect destroyer” – choke their victims to death by blocking their spiracles, or breathing tubes. Killers from the Helotiales, meanwhile, spread through the body cavity in a yeast-like form, exuding deadly toxins.

Forest fronts

Not that death has to be instant: some ant-preying fungi of the genus *Ophiocordyceps* prefer to co-opt their victims as a zombie army first. These brain-manipulating fungi make their hosts climb plants to higher places, and then shoot their spores like bombs from an aircraft, increasing their spread. In their death throes, the ants cling to or bite twigs and leaves, anchoring the fungus in prime positions. Admittedly, your autumnal wanderings would have taken you a long way before you saw this sort of macabre spectacle: *Ophiocordyceps*'s stamping ground tends to be the rainforests of the tropics.

Lest we stray too far towards portraying these particular fungi as evil geniuses, it is worth bearing in mind that altering a victim's behaviour doesn't always play into the perpetrator's hands (were they to have any). Sometimes, the effect of the mind-bending spell is to make ants move like drunkards who have over-imbibed on another fungal product – alcohol. Their erratic movement and insecure footwork then fail them in their high-wire act, and they plummet to the forest floor.

There is more to studying the military tactics of mushrooms than pure voyeurism. Even in the late 19th century, the powdery spores of the white muscardine (*Beauveria bassiana*) and green muscardine (*Metarhizium anisopliae*) fungi were mass-produced in Russia and the US in an attempt to control insect species they parasitise, among them the Colorado potato beetle.

The high cost, when compared with chemical insecticides, and complications in production, storage, distribution and application, meant these initiatives met with limited success. But concerns about the environmental consequences of chemical

Natural born killers



White muscardine (*Beauveria bassiana*)
POACHER TURNED GAMEKEEPER

A deadly attacker of commercial silkworm cultures, this fungus absorbs water and nutrients from its host, causing its body to harden and the wings to drop off adult specimens. The fungus then emerges as a fine white powder of spores that can infect other insects. In natural environments the white muscardine probably helps to control silkworm populations, preventing large-scale defoliation of mulberry trees. It has also been harnessed as a bio-insecticide to control pests such as whiteflies and termites. It is seen here on the surface of a mosquito larva.

control mean “biocontrol” is coming back into favour. With it, there is an increased interest in how fungi's natural chemical arsenals work. Fungal insecticides have the decisive advantage that they can be selected to target specific organisms, minimising unintended harm to other species.

Fungal aggression towards microbes is the origin of our best-known antibiotic, penicillin. Molecular biology tells us that within every



Birch maze gill (*Lenzites betulina*)

SEARCH AND DESTROY

This uncommon parasite of the very common wood-eating turkey tail fungus (*Trametes versicolor*) kills its victim, occupies its territory and exploits its food sources. Its bloodlust not sated, it expands by killing surrounding fungi non-parasitically using volatile and diffusible chemicals.



Ophiocordyceps amazonica

THE EMBALMER

This gruesome customer fills the body of a grasshopper or other insect victim with hyphae and mummifies it. Rather in the manner of the spawn in the film *Alien*, it then erupts through the mummified wall in the summer months to produce a fruit body with a strawberry-like head.



Fly agaric (*Amanita muscaria*)

ONE BITE AND YOU'RE FLYING

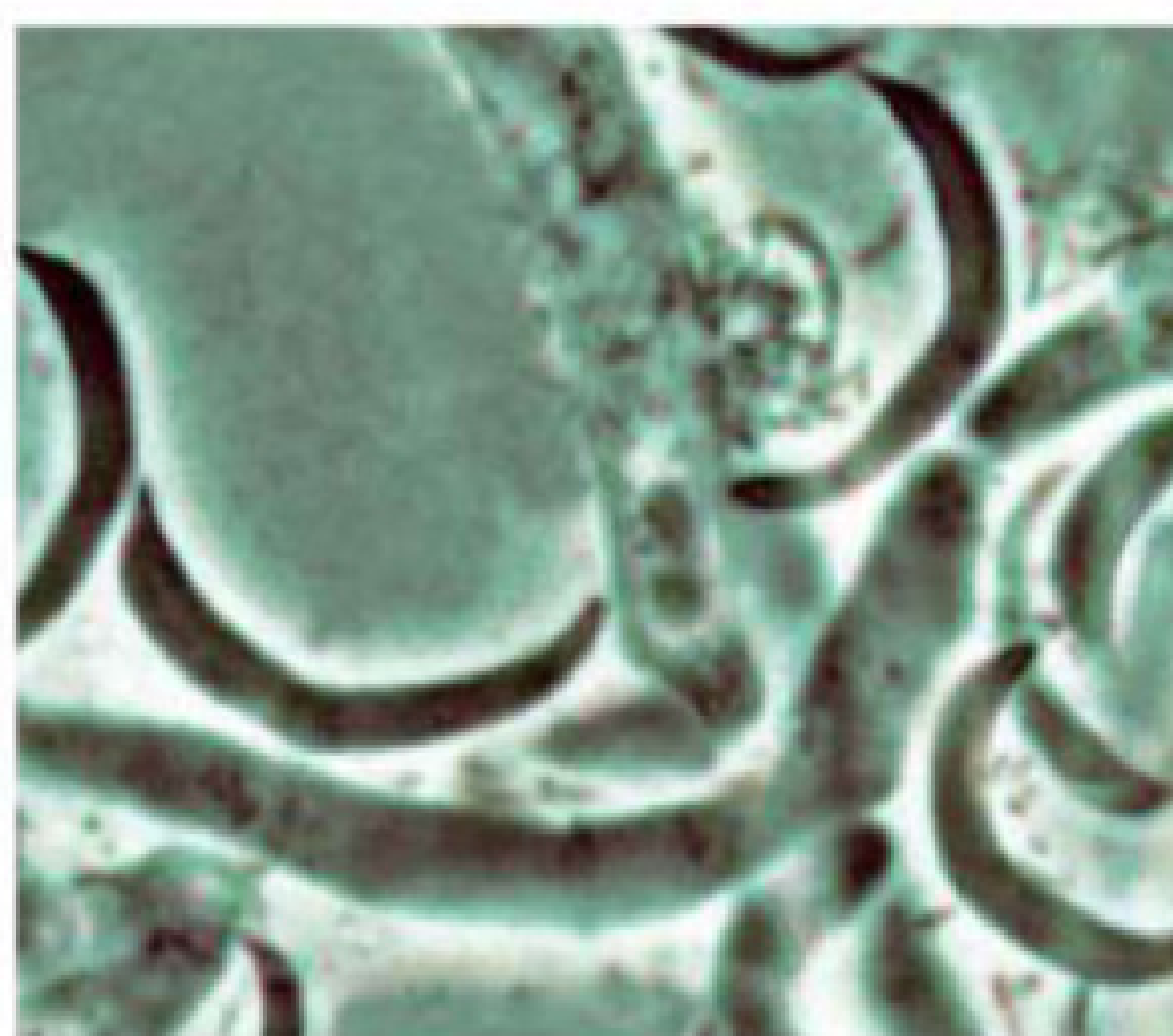
A close relative of the death cap, the classic head of this toadstool is thought by some to be the origin of Santa Claus's costume. It is a serious poisoner with hallucinations to go with it. If Santa ate it he might think his reindeer were flying. Reindeer do eat it, and might think they are flying too.



The death cap (*Amanita phalloides*)

ORGAN GRINDER

A mycorrhizal mutualist that helps to feed woodland trees, the death cap is not good news for us. A human consumer does not know they have been poisoned until 10 or more hours after eating. By that time, the fungal toxins, which inhibit an enzyme critical to cell metabolism, have already caused serious damage to the internal organs starting with the liver. Death usually follows between 6 and 16 days later.



Harposporium crassum

WORM KILLER

Nematodes should beware of the *Harposporia* genus of fungi. Their modus operandi varies. One clan member has sticky knobs on stalks protruding from its hyphae that adhere like limpet mines to nematodes that touch them. Others make spores shaped like sickles, crescents or stiletto heels that stick in the nematode's throat. From wherever the weapon has lodged hyphae grow out and digest the body from inside.



Sulphur tuft (*Hypholoma fasciculare*)

A MULTI-TOOL OF DESTRUCTION

A common sight on tree stumps and fallen wood in deciduous woodlands in Europe and North America, this fungus produces chemicals toxic to some small soil invertebrates (and to us if we ingest them), as well as volatiles with which it can spray competitors. Weapons known as stephanocysts attached to the gills of its attractive yellow fruit body can also capture passing nematodes by adhesion.

fungal genome there are multiple pathways for producing similar killer chemicals – yet just a few are produced when these fungi grow alone in the lab. It's only in the heat of a fight that they turn on the production of a diverse antimicrobial arsenal. Understand what triggers this arms race, and better drugs could be within our grasp.

But how best to get there? In my research group we map out morphing mycelial

networks in the forest in an attempt to better understand the rules of fungal warfare. Back in the lab we set up fungal battles in large trays of soil and blocks of wood, as if setting up games of strategy. We control climate, food and opponents, but the fungi – the “pieces” of our game – move themselves. Will they beat all-comers, or be displaced by some upstart? What weapons or tactics will they use? It is all great fun, and it is tempting to take bets on the

outcome. But more importantly, it gives us a deeper insight into this often overlooked aspect of natural ecosystems like the woodlands we wander in. Through work like this we can better ensure their survival – and perhaps turn them to our advantage. ■

Lynne Boddy is a mycologist at Cardiff University, UK, and currently a Miller visiting professor at the University of California, Berkeley

Pretty meaning

Good infographics don't just crunch numbers, says **Kevin Walker**

Knowledge is Beautiful by David McCandless, William Collins, £25
The Best American Infographics 2014, series editor Gareth Cook/
 introduction by Nate Silver, Houghton
 Mifflin Harcourt, \$20

*London: The Information Capital: 100
 maps and graphics that will change
 how you view the city* by James
 Cheshire and Oliver Uberti, Particular
 Books/Penguin, £25
*Cosmographics: Picturing space
 through time* by Michael Benson,
 Abrams, \$50/£30

FEW words are more important today than “data”, from the Latin for “that which is given”. Entering popular usage in the Renaissance, data gained momentum as a starting point for making inferences or building arguments.

Today, we are awash with the stuff, and we turn to computers to solve a problem they helped to create. But we also turn elsewhere to make sense of those numbers. Visualisation has been heralded both as the photojournalism of the 21st century, and as a way to fill a knowledge gap – with visual analysts, information designers, and graphical storytellers rushing to deploy bubble charts, tree

diagrams and knowledge maps.

The result is that far too many of us take graphics as truth, while far too few designers are trained in the statistics and science underpinning their data. They do not realise how their choices, filters, shapes and simplifications influence how we create meaning. Governments and advertisers, however, know perfectly well that data is political, that it influences opinion (and, yes, science).

Four new books reveal the good, the bad and the unusably complex. Take David McCandless, whose 2009 book *Information is Beautiful* and companion website put him in great demand. In his introduction to the follow-up, *Knowledge is Beautiful*, he writes: “Funny. The more I visualise data, information and knowledge, the more I’m starting to feel and understand the differences between them... Understanding really is the key.” Indeed.

The breezy style exposes a journalistic training, while the typeface of the introduction is unreadable, if pretty. This sets the tone for the visualisations. “I’m into anything strange and interesting,” he writes on his website, and the book is a jumble of graphics visualising everything from “action movie badasses” to a

ridiculous “Life Scape” which classes mammals, reptiles and so forth as “bio-innovations”.

Everything is greatly simplified. One chart classifies dogs as dumb or clever, while overcomplicating the issue with bubbles and multicoloured lines. There is no index, and each chart is in a different style, forcing the reader to decipher a new “language” each time. Pretty, but is it knowledge?

The Best American Infographics 2014 is a similar mix, this time with examples from the US popular media. Gareth Cook is the series editor, and there is an introduction by Nate Silver, a high-profile US statistician. But there are key differences. We learn to distinguish infographics from data visualisation through the contrasts between a hand-drawn diagram dissecting how a baseball pitcher throws a fast ball, a fascinating depiction of how Guantanamo inmates are force-fed, some enlightening maps showing the highest-paid public employees, and what the names of US states mean.

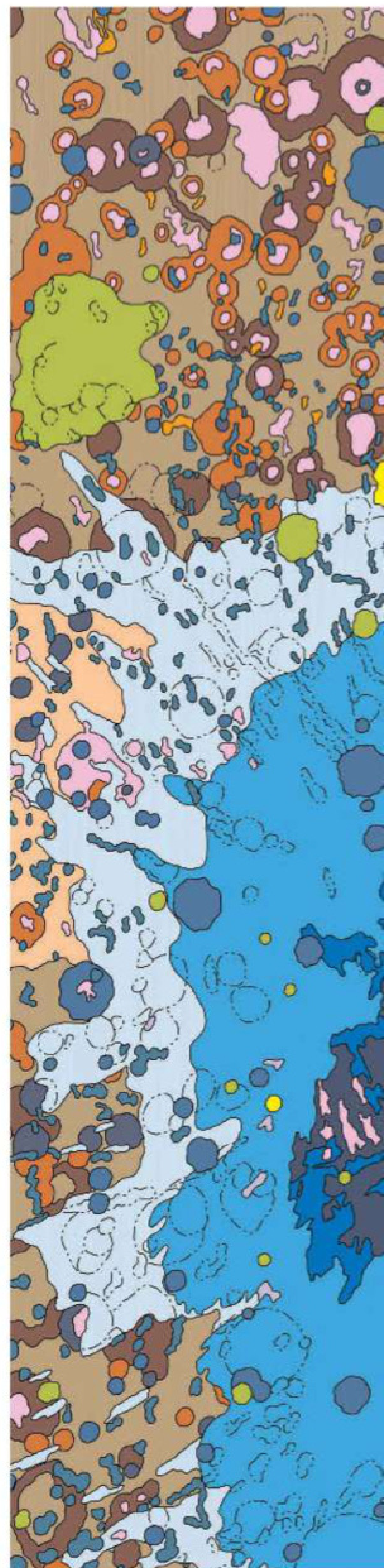
Much of the subject matter is silly in a Justin Bieber/Lolcats way, but there is more science here than in McCandless’s book. And information design, says Silver, is “equal parts art and science, form and function, architecture and engineering”. More is not always better, he tells us. As, indeed, in such “greatest hits” collections of graphics, which risk the cognitive overload that information design seeks to combat.

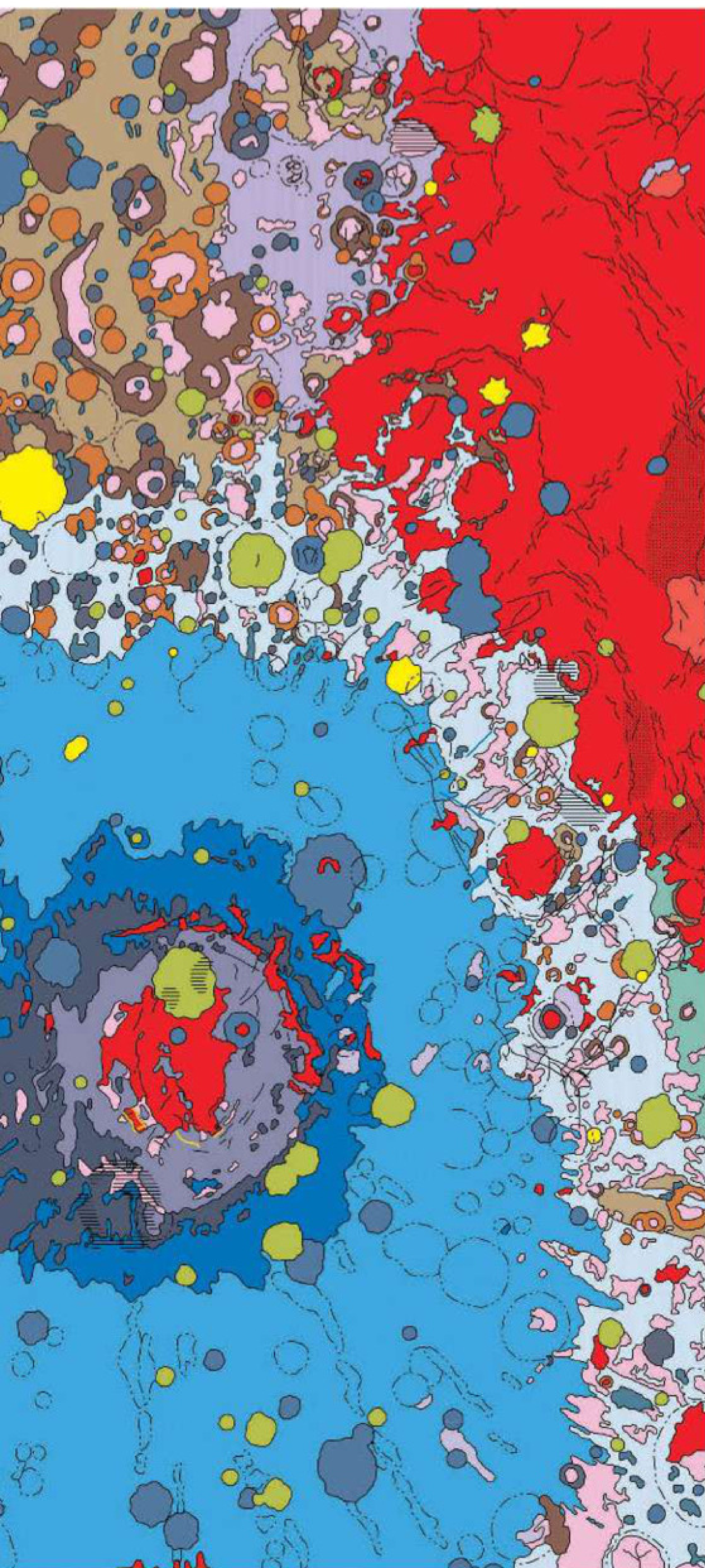
Better, perhaps, to follow James Cheshire and Oliver Uberti, and cover a specific topic that lends itself to great graphics. *London: The Information Capital* is a witty, well-written, well-designed view

**National Maritime Museum,
 London: a view to visualise**



OLIVER UBERTI





Left: a 1970s geological view of the moon. Right: a wind map from 2013

of the city, with enlightening and often surprising perspectives. The authors are well placed to provide them, with Uberti working as a designer at *National Geographic* for nearly a decade, while Cheshire is a geographer at University College London.

Together, they tease readers and lead them on journeys, often literally, as when they show how rents change from west to east along one of the city's underground lines, the Central Line. They are also good at balancing historical sources, such as John Snow's famous 1854 cholera map, with contemporary visualisations of Twitter activity.

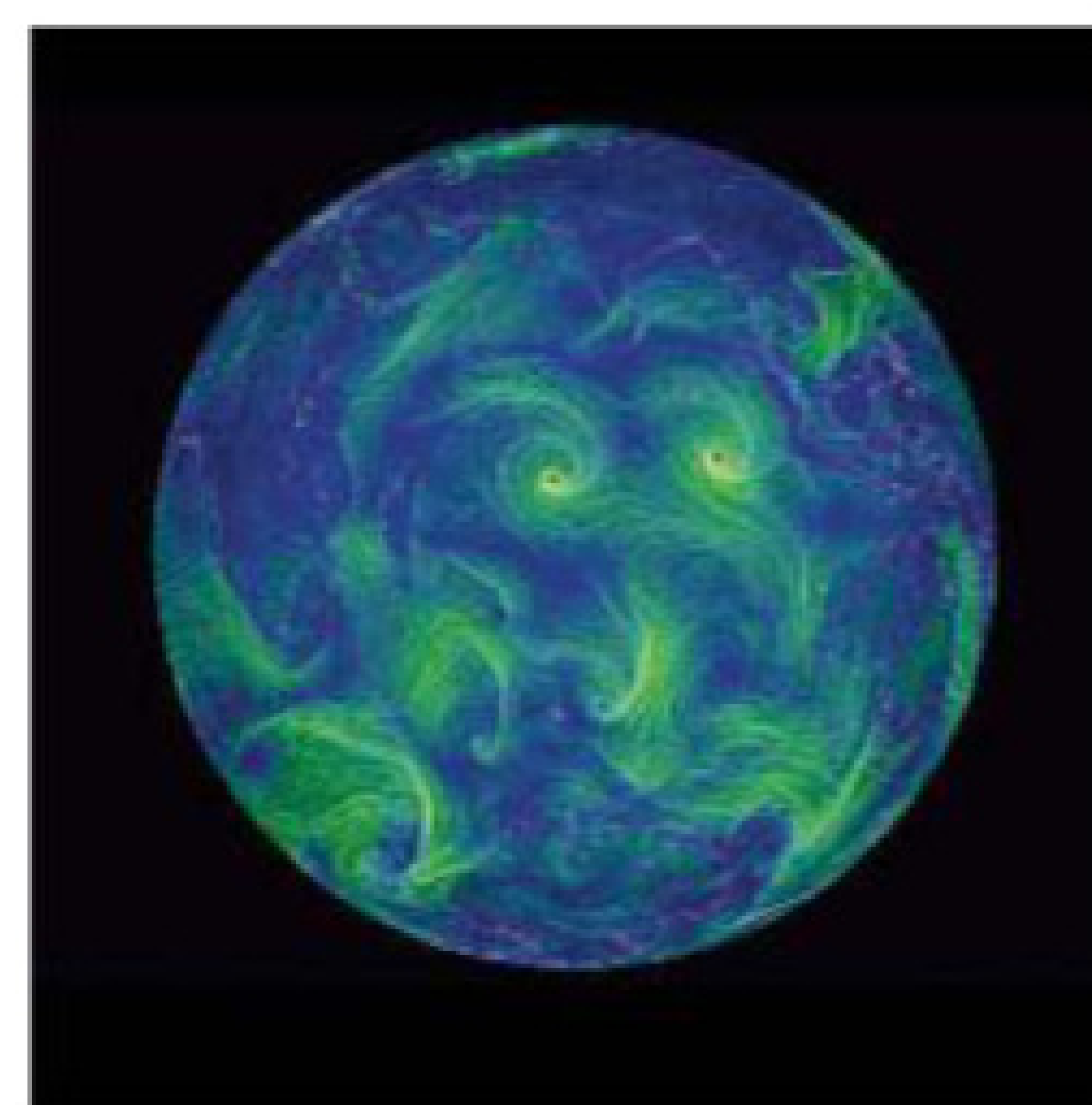
While some things are a little silly or confusing – for example, a map of haunted places is depicted as a Pac-Man game – on the whole, *London* shows how a data-driven approach to knowledge is about

“Information design is equal parts art and science, form and function, architecture and engineering”

more than crunching numbers. The authors tell stories visually, and are not afraid to take a stand. What's more, theirs is an informed, insider's perspective, and it is often beautiful. For example, their series of “views worth protecting” will have you reaching for a watercolour set.

Was knowledge more beautifully depicted before computers? That might be the impression created by the visual interpretations of the cosmos, from antiquity to the present, in Michael Benson's lavish book *Cosmigraphics*. Benson is fascinated by the conundrum of how to present literally everything within a graphic image, and his range is vast, geographically and historically.

Ultimately, is *Cosmigraphics* an art book or a science book? Both, he answers. This is refreshing at a



COURTESY CAMERON BECCARIO, EARTH.NULLSCHOOL.NET

time when the two cultures, intertwined and embodied in the Renaissance figure of a Leonardo, have drifted so far apart. For Benson, visualisation and graphics should be “about” something, noting how early science came to be depicted as meaningful: think of the periodic table or just about any map.

Images are dialectical, too. Our tools shape us and shape science. A symbiosis exists between representation and understanding, “the latter not necessarily preceding the former”, he writes. *Cosmigraphics* is about how science makes pictures of its own processes. Visualisation often makes explicit things we cannot easily see – whether they are insights from a large dataset or invisible wavelengths of energy from a distant star. But, visible or not, whenever we collect data, or decide to use a scatterplot or a pie chart, we make subjective choices which show that science is a human, fallible activity.

I think the historical images in Benson's book trump contemporary infographics, but we shouldn't blame technology so much as those behind it. The explosion in “big data” today is driven by the corporations that traffic in it, and is shaped by technology that, in turn, shapes our culture and science. We need bigger, better critical perspectives. Perhaps alongside visualisation, we should push for provocation. ■

Kevin Walker runs the Information Experience Design programme at the Royal College of Art, London

Up close and personal

Is sex still defying scientific efforts to study it, asks **Simon Ings**

The Institute of Sexology, Wellcome Collection, London, to September 2015
How Sexual Desire Works: The enigmatic urge by Frederick Toates, Cambridge University Press, £27.99
Fuckology: Critical essays on John Money's diagnostic concepts by Lisa Downing, Iain Morland, Nikki Sullivan, University of Chicago Press, £59.50

SEX. It's one of the few subjects about which we know everything and nothing: a paradox facing all who study it scientifically. Sex doesn't have to be private, but most sex acts are, so even when shame is put aside, it's a tricky thing to study. How do you make a science out of more or less desperate fumbling?

To judge by an exhibition on sexology, the first show at a newly refurbished Wellcome Collection in London, researchers were more upbeat in the 20th century.

Take Magnus Hirschfeld, a Jewish radical who collected books, documents and artefacts on sexual behaviour, charted his proclivities in coloured inks, and fought discrimination against homosexuals. His Institute of Sexology, which was ransacked by the Nazis in 1933, gives the name to the Wellcome show.

Then there is Alfred Kinsey, who brought taxonomic skills gained studying gall wasps to the complexities of human sexual behaviour. And in the 1960s and 70s, William Masters and Virginia Johnson observed the sexual responses of anyone for whom they could get ethical approval.

One of the strongest elements of the show looks at Marie Stopes, who was a vigorous advocate of contraception and was opposed to sexual shame.

Today, the British National



On show: in 1896, transvestism was a subject for sexologists

Survey of Sexual Attitudes and Lifestyles, set up in 1990, is one of the few globally to gather the broad information that would have fascinated Stopes. Most of today's cash funds brain-imaging studies or "performance" drugs.

Leaving Wellcome's quiet, informative show, you would be forgiven for thinking its unblushing researchers have gifted us a profounder understanding of ourselves.

On reflection, however, it's hard to say what their work adds up to.

Is sexology a science, or a series of well-intentioned, evidence-based campaigns? Maybe labelling this messy field as science is helpful, securing funding in an age of austerity. For it is the absence of understanding of our needs and desires that matters, showing up over time in illegal abortions, gay-bashing, sexually transmitted diseases and more.

How Sexual Desire Works is psychologist Frederick Toates's stab at a proper scientific account.

He maps the mess as rigorously as he can, and the book is worth it for its bibliography alone. But sexual desire turns out to be as much about boredom, habit, disgust, rage, self-image, disappointment and the like as it is about desire. How to make a science out of this?

John Money, a New Zealand-born psychologist who died in 2006, applied boundless energy to the problem, creating concepts, with their own neologisms, such

"Sex is tricky to study: how do you make a science out of more or less desperate fumbling?"

as "troopbondance". In *Fuckology* (another of his), Lisa Downing and co-authors capture his story ably.

Money was interested in gender identity, and the possibilities for gender reassignment. Depending on what you read, he either tried to eradicate "man" and "woman" as categories, or to link sexuality and gender with a scalpel. After a botched circumcision, David Reimer had gender reassignment surgery at age 2, on Money's recommendation. His miserable life and suicide in 2004 defined the psychologist's reputation.

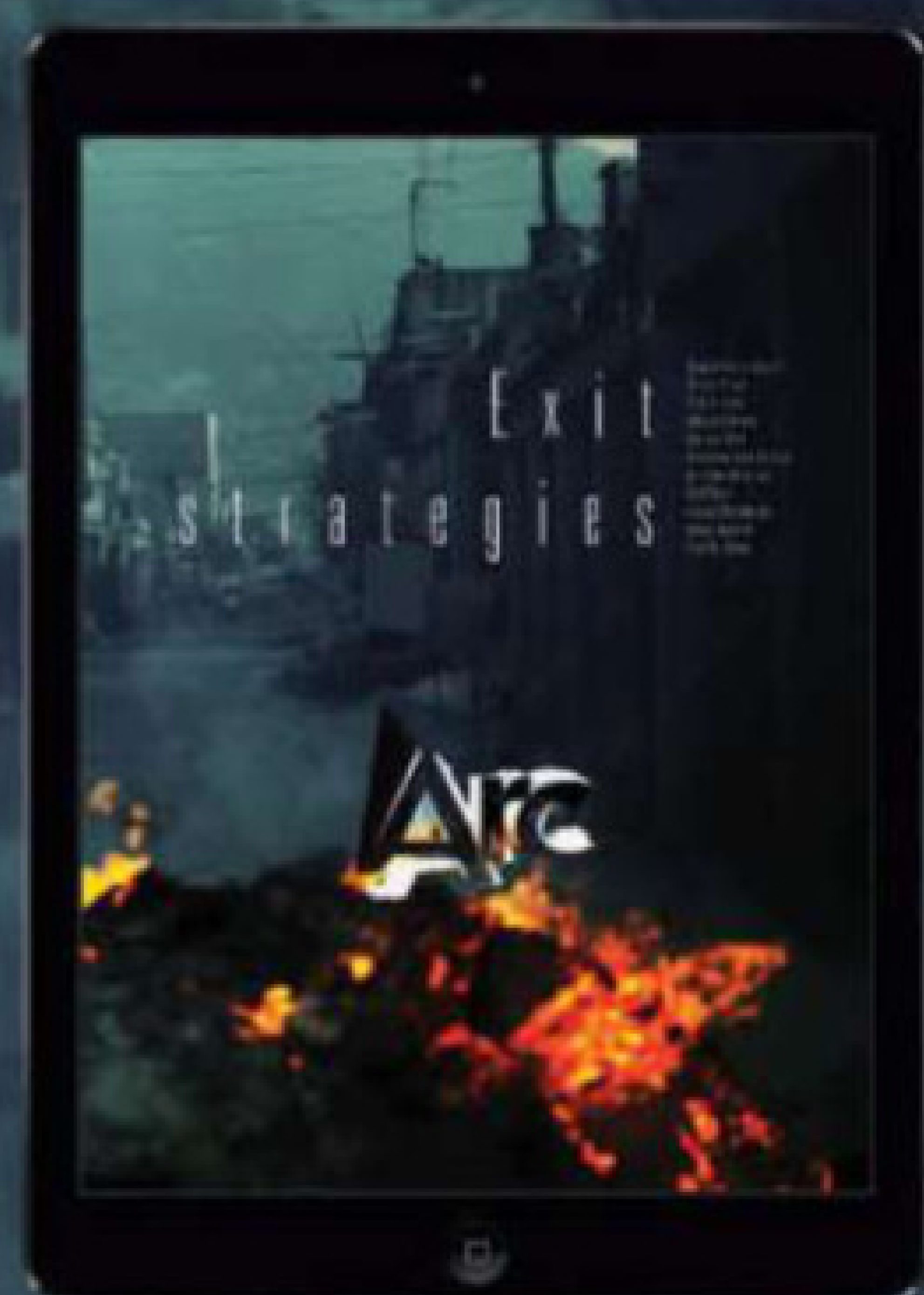
The authors are ironic about Money's approach to his work: "To admit the potential of being wrong, or to settle for the productive tension of ambiguity, is not a feature of Money's rhetorical range..."

But Money is in good company. Sexology lures big personalities: Sigmund Freud was its founder, after all. Have these strong egos bequeathed us a science? It's hard to say. Sex, when push comes to shove, is not for the faint-hearted. ■



Exit strategies

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The Department of Geological Sciences

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Applications should include a letter describing qualifications and interest in the position. Applicants should include a description of relevant experience and accomplishments, a curriculum vitae, and the names and addresses of four references. Review of applications will begin Jan. 15, 2015, but applications will be accepted until the position is filled.

- **Email Applications To:** jsgchair@jsg.utexas.edu
- **Or Mail To:** Search Committee Chair, Office of the Dean
Jackson School of Geosciences
The University of Texas at Austin
2305 Speedway, Stop C1160
Austin, TX 78712-1692

For more information, please visit
www.jsg.utexas.edu



GROWING IANR

Faculty Positions

Institute of Agriculture and Natural Resources The University of Nebraska-Lincoln

The Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska-Lincoln (UNL) is committed to world-class excellence in applications of agricultural and life sciences towards a sustained high quality of life for the citizens of Nebraska, and for a quickly growing global population. Early in 2013, reflecting this commitment, IANR launched an initiative to hire new tenure-track faculty members in strategic impact areas of Science Literacy; Stress Biology of Plants, Animals, and Agroecosystems; Healthy Humans; Healthy Systems for Agricultural Production and Natural Resources; and Computational Sciences. This Phase 1 effort was very successful, resulting in the recruitment and hiring of 35 highly skilled tenure-line faculty members (with two searches still active).

We are pleased to announce Phase 2 of this effort with recruitment for an anticipated 30+ additional tenure-line faculty positions. The focus for Phase 2 will be to strengthen the six strategic impact areas in Phase 1, with an additional focus area – Drivers of Economic Vitality for Nebraska.

We invite you to view brief explanations of the positions currently being released and those to be released soon at <http://ianr.unl.edu> to explore whether your skills and experience make you a good fit for our team.

The positions will be advertised and posted beginning December 1, 2014. We invite you to visit the UNL employment web site at <http://employment.unl.edu> to learn which positions are posted.

The University of Nebraska is committed to a pluralistic campus community through affirmative action, equal opportunity, work-life balance, and dual careers.



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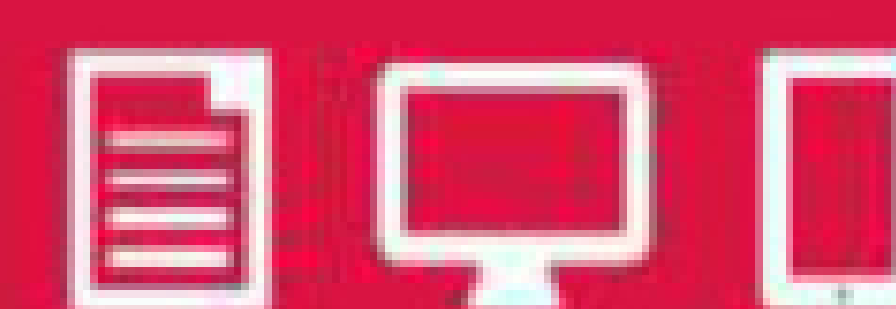
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NewScientist Jobs

Research Scientist for Next-Generation Sequencing and Bioinformatics

The Wadsworth Center (Albany, NY) is seeking an outstanding scientist to join its Public Health Genomics Center. The successful applicant will be responsible for the development and implementation of next-generation sequencing and associated bioinformatics analyses in the research and public health programs of the Center. He or she will collaborate with research scientists to develop cutting-edge approaches for applications such as, pathogen identification, outbreak tracking, mapping drug-resistance determinants and novel genetic testing. In addition, there will be opportunities to participate in the various educational activities offered by the Wadsworth Center.

The Wadsworth Center (www.wadsworth.org) is the country's most comprehensive state public health laboratory with a staff of about 750. The Center provides a dynamic research environment focused on infectious, genetic and environmental diseases and their impact on human health. Through its initiative for Public Health Genomics, the Center will bring NGS and other advanced molecular technologies to public health testing, diagnosis, and research, further develop these technologies to address new and emerging challenges, and become a regional center of excellence for NGS in the area of public health genomics.

Ph.D. degree or equivalent and one to two years of relevant postdoctoral research preferred. Experience with various approaches for sample preparation for sequencing of microbial specimens and applications of different sequencing strategies is desired. Applicants should submit a cover letter, curriculum vitae, and contact information for at least three references to wcphgc@health.ny.gov, referencing posting RS3/4/12137. Applications will be accepted until the position is filled and reviewed as they are received. AA/EOE.

Wadsworth Center
NEW YORK STATE DEPARTMENT OF HEALTH



UNIVERSITY OF UTAH
HEALTH SCIENCES

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Huntsman Cancer Institute
Department of Oncological Sciences

The Department of Oncological Sciences and Huntsman Cancer Institute (HCI) invite applications for an **associate professor** or **professor** in the tenure track. We seek an outstanding PhD, MD, or MD/PhD cancer biologist with a well-established laboratory-based research program centered on cancer mechanisms and/or tumorigenesis models, with translational focus or potential. Mechanistic topics might include cancer genetics, cancer cell metabolism, cell cycle control, signal transduction, cell death, gene expression, epigenetics, DNA repair, tumor microenvironment, metastasis, and oncogene/tumor suppressor function. Translational emphasis might include molecular diagnostics, preclinical tumor models, and investigational therapeutics. Departmental strengths include transcriptional regulation, epigenetics, human cancer genetics, stem cell biology, mouse, zebrafish and fly models of cancer, cell signaling pathways, apoptosis, DNA repair, cell motility, and cancer metabolism. HCI is an NCI-designated cancer center with state-of-the-art laboratories and shared resources, including core facilities for imaging, genomics, drug screening and in vivo pre-clinical testing, and population studies. We offer a collegial and interactive research environment and robust graduate programs for training PhD and MD/PhD students.

Review of applications will continue until the position is filled or the search is closed.

For full consideration please apply at the following link:
<http://utah.peopleadmin.com/postings/36883>

Inquiries may be submitted to Recruitment Director at
hci.recruitment@hci.utah.edu

The University of Utah Health Sciences Center is a patient focused center distinguished by collaboration, excellence, leadership, and Respect. The University of Utah HSC values candidates who are committed to fostering and furthering the culture of compassion, collaboration, innovation, accountability, diversity, integrity, quality, and trust that is integral to the mission of the University of Utah Health Sciences Center.

The University of Utah is an Affirmative Action/Equal Opportunity employer and does not discriminate based upon race, national origin, color, religion, sex, age, sexual orientation, gender identity/expression, status as a person with a disability, genetic information, or Protected Veteran status. Individuals from historically underrepresented groups, such as minorities, women, qualified persons with disabilities and protected veterans are encouraged to apply. Veterans' preference is extended to qualified applicants, upon request and consistent with University policy and Utah state law. Upon request, reasonable accommodations in the application process will be provided to individuals with disabilities. To inquire about the University's nondiscrimination or affirmative action policies or to request disability accommodation, please contact: Director, Office of Equal Opportunity and Affirmative Action, 201 S. Presidents Circle, Rm 135 (801) 581-8365.

The University of Utah values candidates who have experience working in settings with students from diverse backgrounds, and possess a demonstrated commitment to improving access to higher education for historically underrepresented students.

Software Developer Upstream Oil and Gas - Houston TX, US

Tessella is a global analytics, software services and IT consulting company that works with some of the world's leading organizations in energy, pharmaceuticals, consumer goods and the public sector to solve complex, real-world problems. We are currently looking to recruit a software developer, preferably with exposure to the Oil & Gas industry.

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- Helping our customers to better understand their data to improve their processes.

Requirements

- Bachelors / Masters degree in engineering or science (ideally in geophysics, geotechnical engineering, petroleum engineering or similar). A PhD is a plus.
- Experience of technical / scientific software development in either C#, C++, .NET or Java.
- Excellent communication skills and the ability to explain complex technical solutions to customers and colleagues from all backgrounds.
- It would be an advantage to have experience of oil/gas exploration, drilling, geophysical or seismic industry and/or relevant commercial software tools. This experience could have been gained through an internship or academic studies, if not professionally.

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In addition to a competitive salary and benefits, we offer an annual training allowance of 150 hours to each employee, which can be used to learn technical or soft skills or earn recognised professional qualifications.

As your career progresses, we offer good future prospects. A technical career path is open to staff who wish to focus on technology and become technical architects of our software. Alternatively a project management / leadership route is available for staff who wish to develop their organizational and people management skills.

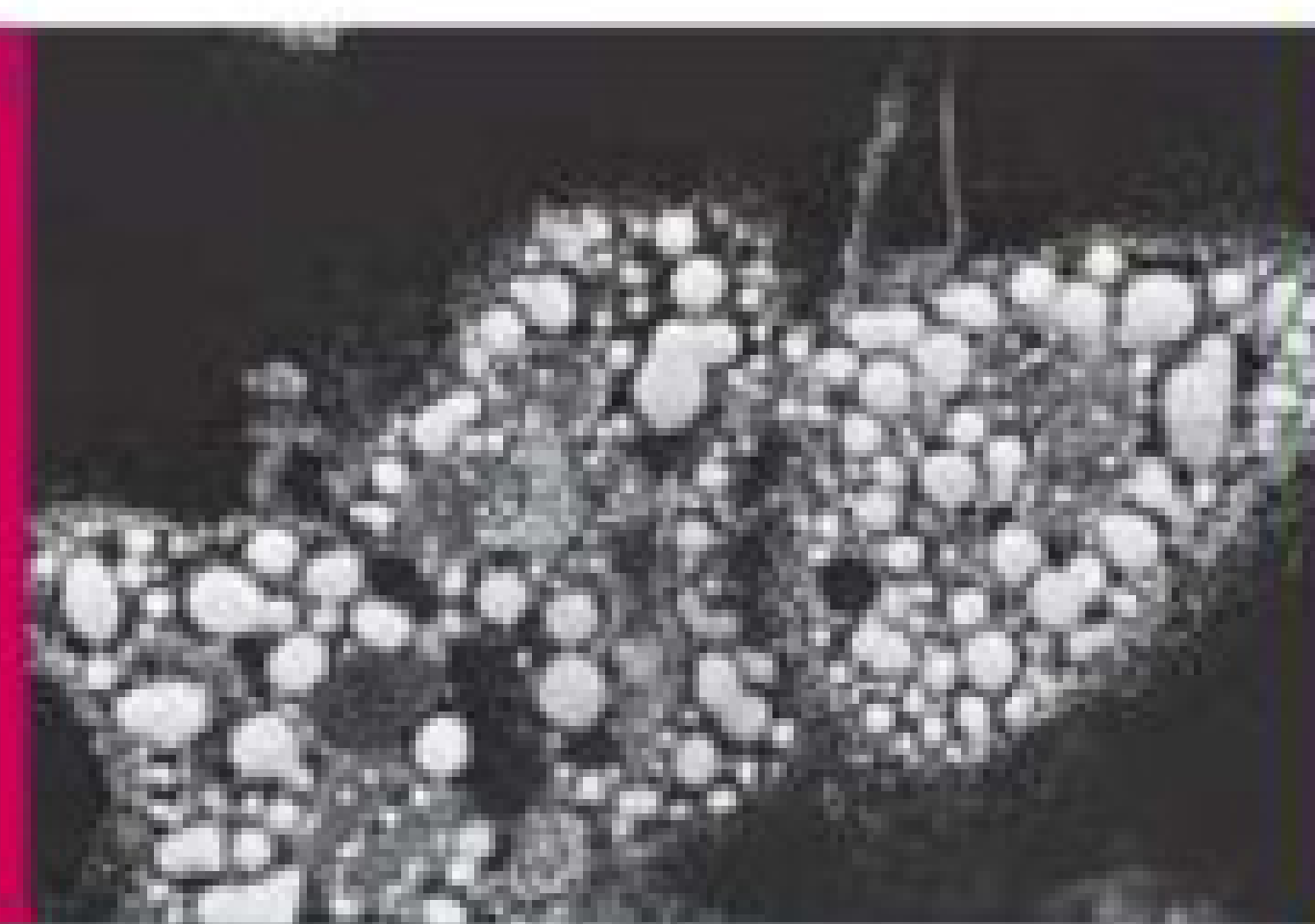
About Tessella

Tessella is a global analytics, software services and IT consulting company that works with some of the world's leading organizations in energy, pharmaceuticals, consumer goods and the public sector. In the oil and gas sector, Tessella helps the science and engineering teams of leading energy organizations to meet critical business goals, from improving safety and protecting the environment to enhancing decision support and knowledge sharing. We are also experts in the fields of big data and analytics, and our energy clients rely on us to help them draw meaningful conclusions from the flood of oilfield data.

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PROFESSOR AND CHAIR THE FISCHELL DEPARTMENT OF BIOENGINEERING UNIVERSITY OF MARYLAND, COLLEGE PARK

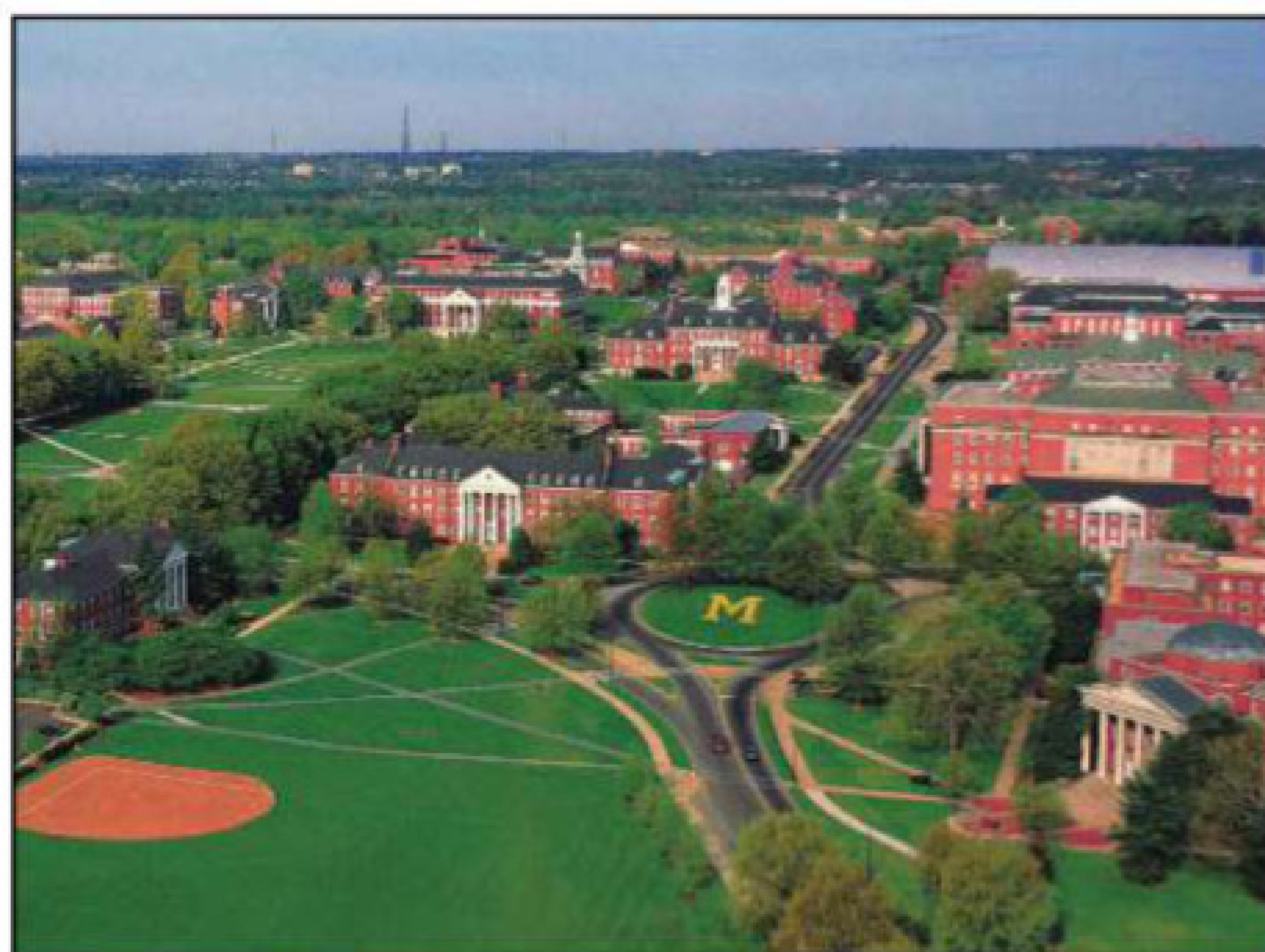
Applications are invited for the position of Chair of the Fischell Department of Bioengineering at the University of Maryland. Responsibilities include leadership of a research-active academic department, program development with industrial partners, government labs and foundations, and stewardship of strong academic programs. Applicants should have an earned doctorate in bioengineering or a closely related field; leadership ability with excellent interpersonal skills; a proven research record with international recognition; and a commitment to engineering education. Applicants must be qualified for appointment as a tenured full professor in the Department.

In 2017, the Fischell Department of Bioengineering will move into A. James Clark Hall. This 184,000-square-foot building will house world-class research and educational facilities and the Robert E. Fischell Institute for Biomedical Devices <http://www.eng.umd.edu/clarkhall/>. The Fischell Department of Bioengineering

currently has 20 regular faculty (with plans to expand), 17 affiliate faculty members and 9 staff members, 400+ undergraduate students, 75 graduate students and more than \$8 million in annual research expenditures. More information at: <http://www.bioe.umd.edu>. Questions can be addressed to: Chair-SearchComm-BIOE@umd.edu.

For best consideration, applications should be submitted to <http://ejobs.umd.edu/postings/30410> (Position number 105571) by 1/30/2015. Applications should include a cover letter, complete curriculum vitae (resume), and contact information for five references.

The University of Maryland is an equal opportunity affirmative action employer.





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At AstraZeneca, we're proud to have gained a host of awards for our progressive and diverse working practices. But we never rest on our laurels. Each award we receive pushes us further, and strengthens the connections between fellow employees, patients, stakeholders and the communities we serve and value.

Here are some of the awards we have recently been honoured with:

AstraZeneca was named a top 10 company for Executive Women in 2014's National Association for Female Executives Awards.

Committed to increasing the number of women in senior roles, we set exacting goals. Two years ago, AstraZeneca announced that by 2015 we wanted women to represent 38% of our talent pool, and 43% of senior managers worldwide. These numbers have already reached 34% and 40%.

The Human Rights Campaign Foundation handed AstraZeneca the Best Place to Work for LGBT Equality 2014 Award.

We received a high score on the 2014 Corporate Equality Index (CEI), a national benchmarking survey on corporate policies and practices relating to lesbian, gay, bisexual, and transgender (LGBT) workplace equality.

AstraZeneca is a global, top 100 InDemand Employer, as recognized by LinkedIn in 2013.

As one of the world's most attractive employers, we appear on LinkedIn's Global 100 InDemand Employers list - based on billions of interactions between LinkedIn's 238 million members.

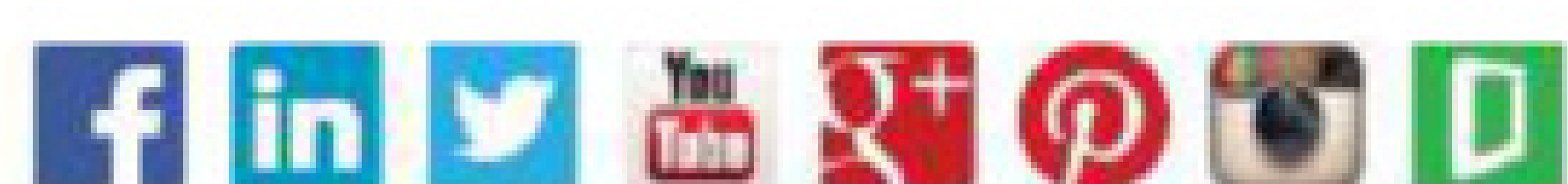
We were the winner of the Opportunity Now Global Award in 2013.

This award is given for pursuing a positive gender initiative across at least three countries. It was awarded to AstraZeneca for our 'Asia for Global' talent development programme.

Other awards we have been delighted to receive include:

- Hispanic Choice Award - Alianza Award for Company of the Year (2014).
- Working Mother Magazine's 100 Best Companies for Working Mothers (2014).
- Three AstraZeneca employees were named in Diversity MBA Magazine's list of top 100 under 50 diverse emerging leaders (2014).
- Philadelphia Business Journal's Healthiest Employers Awards (2014).
- NBGH Best Employers for Healthy Lifestyles® Awards (2014).
- Washington Business Journal's 2014 Healthiest Employer Award.

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IQC Institute for
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Faculty Positions

Applications are invited for 1 or more tenured/tenure-track faculty positions at the Institute for Quantum Computing (IQC) and any department in the Faculties of Engineering, Mathematics and Science. The IQC is a collaborative research institute focused on realizing quantum technologies including sensors, actuators, quantum communication, and information processors. Membership in IQC is renewable, with an initial appointment of 5 years, and comes with research space, a teaching reduction of one course and a stipend. Only those candidates whose research program directly connects with the goals and ongoing research in IQC will be considered. Information about research at IQC can be found at <http://uwaterloo.ca/iqc/research>

A PhD and significant evidence of excellence in research in quantum information science and technology and the potential for effective teaching are required. Responsibilities include the supervision of graduate students, as well as teaching at the undergraduate and graduate levels. Based on qualifications, rank hired at and Faculty/Dept. cross-appointed to, salary range of \$75,000 to \$185,000 will be considered. Negotiations beyond this salary range will be considered for exceptionally qualified candidates. Effective date of appointment is negotiable. The search is open to all areas of quantum information and all faculty levels. The search committee will consider all creative and energetic candidates in any area of research focused on advancing quantum information.

The University of Waterloo is host to the Institute for Quantum Computing. At present, IQC has a complement of 22 faculty members (growing to 33) from the Faculties of Engineering, Mathematics and Science. Interested individuals should upload their application via the faculty application form at: <http://uwaterloo.ca/iqc/positions>.

The application review process will begin on December 1, 2014 and continue until March 31, 2015.

The University of Waterloo respects, appreciates and encourages diversity. We welcome applications from all qualified individuals including women, members of visible minorities, Aboriginal peoples and persons with disabilities. All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority.

Three reasons to apply: <https://uwaterloo.ca/watport/why-waterloo>.

Fellowships for Postdoctoral Scholars

Woods Hole Oceanographic Institution



New or recent doctoral recipients with research interests associated with the following are encouraged to submit scholarship applications prior to January 5, 2015.

Departments - Awards related to the following areas are anticipated: Applied Ocean Physics & Engineering; Biology; Geology & Geophysics; Marine Chemistry & Geochemistry; Physical Oceanography; and in cooperation with the USGS laboratory located on the WHOI campus.

Institutes - Each Institute fosters interdisciplinary research addressing critical issues, and we will award a scholarship to support related research: Ocean and Climate Change Institute; Coastal Ocean Institute; Ocean Exploration Institute; Ocean Life Institute.

The Center for Marine and Environmental Radioactivity (CMER) will award a fellowship for research on natural and human-made radioactive substances in the environment including the study of their sources and fate or use as tracers of ocean processes.

Awards are competitive, with primary emphasis placed on research promise. Scholarships are 18-months with an annual stipend of \$58,000, a research budget and eligibility for health and dental insurance. Recipients are encouraged to pursue their own research interest in association with resident staff. Communication with potential WHOI advisors prior to submitting an application is encouraged.

Further information may be obtained at:

www.whoi.edu/postdoctoral

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WE SHOULD have guessed that the blog flyingcarsandfoodpills.com - dedicated to "the visionaries, madmen, and tinkerers who created the future that never was" - is by a Feedback reader. Steve Carper sends a 1911 image from *Life*, then a weekly humour magazine, answering our call for premonitions of the internet.

We had mentioned a "typical home of the future" in *Modern Mechanics* magazine in June 1931, with a "radio newspaper" (15 November). Steve's picture has a gentleman surrounded by horns of the kind that used to adorn wind-up gramophones, one offering "opera delivered at your door". And, yes - to one side is the "International Wireless Home News Service": a brass-pointer "menu" selects politics, stocks, sports and so on. But no kittens :-)

OPERA delivered to your door? You could get that in Budapest from 1893 on the Hungarian city's broadcast telephone service,

Telefon Hírmondó. You could pick up a phone and listen to the news or music. The service continued until bombs cut the wires in 1944.

An even less well-known service, the Electrophone, served London from 1895 until the dawn of the BBC in 1922 doomed it.

ALSO sent by Steve Carper is a "Guess at futurity" by Fred T. Jane, known now as the founder of *Jane's Fighting Ships*. In October 1894, he produced the illustration *Home Life in Anno Domini 2000* in *Pall Mall Magazine*. This vision of the future featured cathedral-like sitting rooms with 5-metre flat screens and news on a capstan-controlled scroll.

MARK TWAIN was the author of the earliest premonition of the internet we found, in his 1898 story *From the "London Times" of 1904* (15 November). Richard Jones comfortably trumps this with a cartoon by George du Maurier

from *Punch* in 1878, which shows fond parents in London using "Edison's Telephonoscope" to keep an eye on their offspring in the colony of Ceylon (now Sri Lanka). It is a combination of speaking tubes and a screen that takes up a whole wall - and surely throws into question patents on video-calling services?

BEATING all the above, Craig Hanson sends a passage from Nathaniel Hawthorne's 1851 novel *The House of the Seven Gables*: "Is it a fact... that, by means of electricity, the world of matter has become a great nerve, vibrating thousands of miles in a breathless point of time? Rather, the round globe is a vast head, a brain, instinct with intelligence!"

TELEPHONOSCOPE: a word to be treasured. It gives us a data point in our parallel search for repeated videophone announcements (22 November). Jeff Hecht digs into the notes for his book *City of Light*, a history of fibre optics. He finds a report by, er, himself in *New Scientist* (15 September 1990, p 36). If we had more data points, we could check whether these premonitions present periodicity.

DISAPPOINTMENT in the actually existing 21st-century internet is invoked by another result of Jeff Hecht's research into videophones. A famous book-scanning engine produces the phrase "mother called us on the videophone one evening..." It attributes this to *Soviet Literature*, which it says was published in 1870. We are puzzled: the first Russian workers' council "soviet" was in 1905.

BIG DATA is a buzz phrase of the year, not least around here. Steve Cassidy is sceptical. It seems to him that the commercial premise is that given enough information, Skynet - defined not as the antagonist of the *Terminator* films, but as "shallow-minded marketing men shouting at downtrodden minimum-wage database programmers" - can "deduce our innermost desires

and parade in front of us those *tchotchkes* that are most likely to make us open our wallets and drain our self-control". (Feedback is not aware of any other language having an exact synonym for the Yiddish "*tchotchke*", a trinket of no discernible function.)

So why, then, he asks, "did the *Daily Telegraph's* rolling advert provider decide that what I needed to see, while reading about the UK Independence Party's Nigel Farage, was the "Greta Garbo Ankle Weight Set", designed for minimal chafing and wearable under today's fashionable jeans? I am a 52-year-old white male consultant, garrulous online..."



FINALLY, a more physical scam has, we hear, befallen a friend of a friend of Feedback. A distraught young woman knocks on the door. Her car has broken down and she needs to collect her child from school. Her cellphone battery is flat. Can she please use your phone to call the school and car rescue service? It takes a while, but she is very grateful.

Later, the phone bill arrives. She was calling high-cost premium numbers - presumably to rack up charges for a company she's working for. The friend of a friend advises: "Be kind, but dial the numbers yourself."

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Ah, technology. Making life easier. Rod Costigan sends a screenshot: "Internet Explorer 11... did not finish installing. Internet Explorer 11 is required in order to run this installation"

Tired tyres

Standing next to a busy highway, most noise comes from car tyres. Is there any way to reduce this noise while keeping the more desirable properties of tyres, such as traction?

■ The noise comes from tyres' interaction with the road surface. Hence the nature of the surface can make a big difference to the noise produced. Many motorways in my native country, the Netherlands, are being surfaced with ZOAB, the Dutch acronym for very open asphalt concrete. The surface's high porosity allows sound to dissipate downwards, as well as upwards and sideways, creating markedly less noise. The dampening effect is noticeable both outside and inside vehicles. Another advantage is a reduction in spray in wet conditions.

Traction is deemed to be acceptable on these surfaces, but is reduced compared with typical road surfaces, especially when the ZOAB is new. That's why you will see signs saying "new road surface; increased braking distance" along recently surfaced stretches of these motorways.

The other downside is the increased need for salting in winter. The wet nooks and crannies in the ZOAB surface are perfect hidey-holes for ice. These road surfaces break up more easily as well, and need to be relaid more frequently than solid asphalt.

Jan Meulendijk

Haverfordwest, Pembrokeshire, UK

■ There has been a great deal of research into this topic in the EU over the past 20 years. During the time I worked on traffic noise at the UK's Highways Agency, a range of quieter surfaces were developed. Long-term trials were undertaken to monitor their resistance to wear and skidding performance, as well as the amount of noise emitted in a standard roadside test.

Part of the problem arises as tyres interact with surfaces that are deliberately roughened to improve skidding resistance. Concrete has been used extensively in the US because it is durable and economical for long stretches of road, but it is difficult to create smooth rolling surfaces in concrete while ensuring the right texture for good skidding resistance.

Efforts have been made in the US to retexture some older concrete roads using diamond saws to cut longitudinal slots in the surface, which help to disperse water. This doesn't necessarily generate as much

"Concrete is durable but it is difficult to create smooth rolling road surfaces with good skidding resistance"

tyre noise as the transverse-brushing process that has been used to provide skid resistance on concrete roads in the UK. However, sawing and regrinding concrete is a slow and expensive process.

Peter Kinsey

Llangybi, Monmouthshire, UK

Crash, bang, wallop...

Why do loud noises seem to hurt?

They don't seem to cause physical pain but do induce mental anguish. I heard a truck taking on board a bin of empty bottles and the noise was excruciating. I had to get out of earshot.

■ Two factors contribute to the unpleasantness of the noise from bottles going into a truck: the volume, and the discordant frequencies. The human ear detects sound using tiny hair cells in the cochlea. A sound wave causes mechanical deformation of these cells, sending an electrical signal to the brain via the auditory nerve. Different groups of hair cells react to different frequencies, with hairs detecting low notes at one end of the cochlear spiral and high notes at the other.

High volumes can damage the delicate hearing apparatus, from chemical exhaustion of the cell-signalling process and mechanical damage. We are adapted to find damaging stimuli unpleasant and painful so that we avoid them.

Humans also find notes that are too close together very unpleasant – think of the discord between two adjacent notes on a piano, compared with reasonably pleasant sounds obtained by playing notes spaced apart. This is probably because the closeness of the frequencies means there is an overlap in the groups of hairs activated by each note, overstimulating those that can sense both.

Glass colliding as it is dumped into the truck creates many discords at once.

For high notes, like the crash of breaking glass, the problem is worse because as the notes get higher, the difference between adjacent notes gets smaller, and more hairs will be stimulated by a given note. We are therefore more likely to experience discordance at higher frequencies.

Miriam Ashwell

London, UK

■ Rather than the ear damage, the issue here could be hyperacusis – an oversensitivity to certain types of sound. Some of us might have experienced this during a hangover, when even tiny noises seem dreadful.

Hyperacusis can occur on its own, or as part of a number of medical conditions. As a doctor, I see this most often in migraines.

Having said this, the questioner probably doesn't have true hyperacusis. His account sounds more like he has an aversion to that one particular sound. Now my kids are growing up, it's wailing babies that set my nerves on edge, giving me the greatest urge to run for the hills.

Robert Ewing

Edinburgh, UK

This week's question

ZZZZZZCHOOO...

Why don't we sneeze in our sleep?

Tony Sandy

Kilmarnock, Ayrshire, UK

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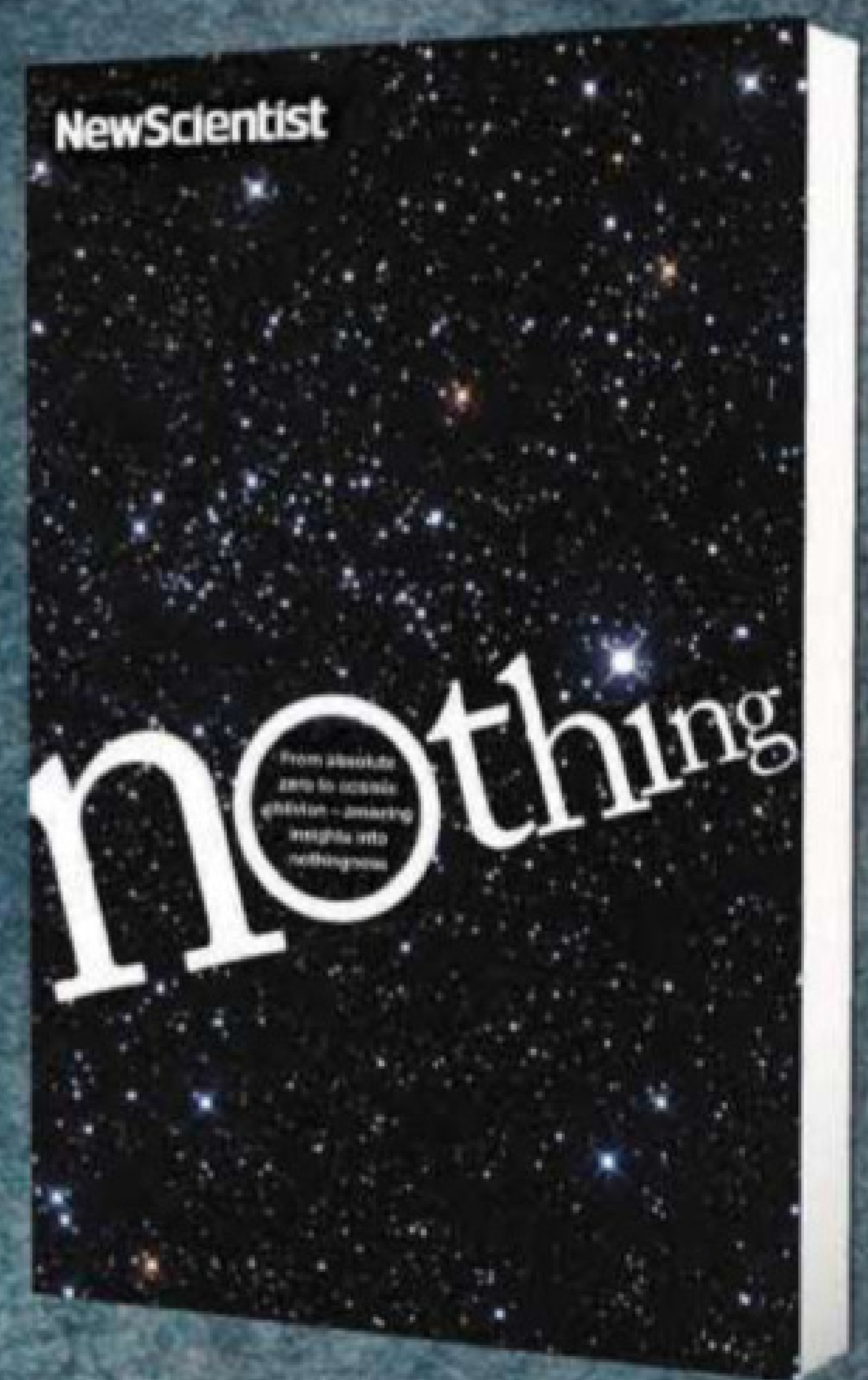
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